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RELATIVE VITAMIN A CONTENT OF FOUR ORIENTAL FOODS

By HARTLEY EMBREY SHERMAN

Of the Laboratories of Food Chemistry, Peking Union Medical College Peking, China, and the Bureau of Science, Manila [1]

SEVEN TEXT FIGURES

Small quantities of the foods described in this paper were introduced into a basal diet deficient in vitamin A. White albino rats were used as experimental animals. In the experiment with persimmon, a weighed amount of the fresh fruit was fed by hand and then the basal diet was given ad libitum. All of the other foods tested were prepared by cooking in an autoclave for forty minutes at 15 pounds pressure, and dried in a current of air below 60° C. These dry foods were then powdered and incorporated in the basal diet so intimately that the rats could not separate the different food substances. Table 1 shows the results of the experiments.

TABLE 1.—*Showing the results of feeding certain foods to white rats.*

No.	Description or English name of the food tested.	Local name in the Peking dialect and, when possible, in Tagalog.
1	Chinese persimmon	Shih tzŭ (Chinese); called, erroneously, "pagatpat" by the Filipinos.
2	A pot herb with a yellow flower	Huang hua ts'ai (Chinese); called, incorrectly, "bulaklak nang saguing" by the Filipinos.
3	Yellow soy-bean curd (the precipitated proteins of the yellow soy bean).	Tou fu (Chinese); utao (Filipino).
4	------(?)	Kan lu.

[1] The work at the Peking Union Medical College was done with the help of Mr. Tsan Ch'iang Wang, to whom much credit is due.

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TABLE 1.—*Showing the results of feeding certain foods to white rats.*—Cont.

No.	Scientific name.	Minimum amount of food tested necessary for normal growth and the prevention of xerophthalmia.	Remarks.
1	*Diospyros kaki* Linnæus f.	Two grams of fresh persimmon daily cures xerophthalmia; 5 grams daily gives normal growth.	Abundant source of vitamin A.
2	*Hemerocallis flava* Linnæus	Five per cent of the total diet cures xerophthalmia and gives normal growth.	Do.
3	*Glycine max* Linnæus	Thirty per cent of the total diet gave stable weight, but the growth was subnormal.	Fair amount of vitamin A.
4	(?)	Forty per cent of the total diet gave subnormal growth.	Small amount of vitamin A.

CONCLUSIONS

Chinese persimmon and the flower of *Hemerocallis flava* Linnæus (huang hua ts'ai) are rich in vitamin A. Bean curd has only a moderate amount of vitamin A, and kan lu has an even lower vitamin A content.

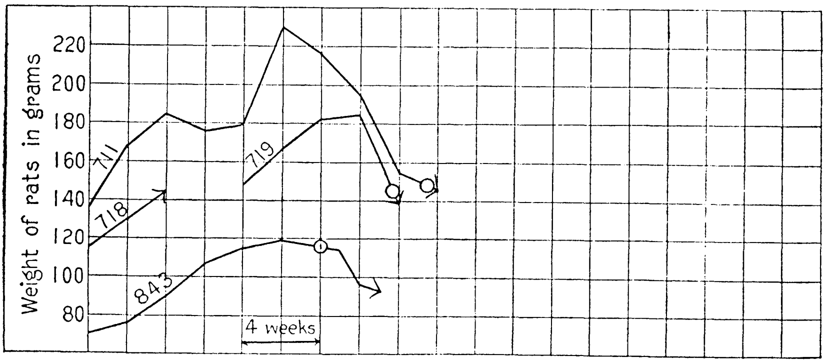

FIG. 1. Rats 711, 718, 719, and 843 received the basal diet which consisted of purified dry casein (extracted with absolute alcohol three times) 18 per cent. Our standard salt mixture consisted of sodium chloride (NaCl), 0.173 gram; magnesium sulphate ($MgSO_4$), 0.266 gram; sodium sulphate (NaH_2PO_4), 0.347 gram; dipotassium phosphate (K_2HPO_4), 0.954 gram; calcium phosphate [$CaH_4(PO_4)_2$], 0.540 gram; ferric citrate, 0.118 gram; and calcium lactate, 1,300 grams. This salt mixture, 4 per cent; dry brewers' yeast (extracted with absolute alcohol three times); purified dry starch prepared from mung bean (extracted with absolute alcohol three times), 68 per cent. All of the rats died, and all showed severe xerophthalmia. This disease developed more rapidly in young rats given the diet than it did in the old ones.

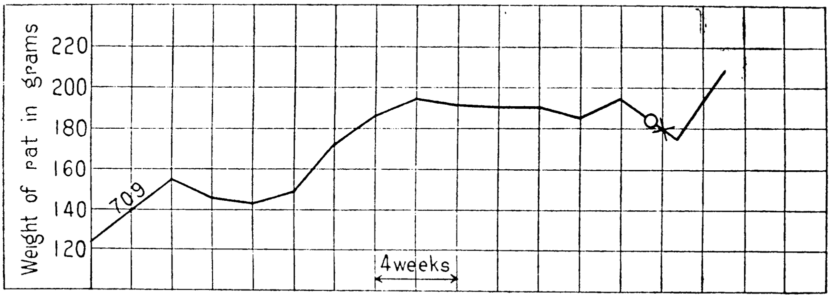

FIG. 2. Rat 709, fed the basal diet, developed a severe case of xerophthalmia. This was cured by the feeding of 2 grams of fresh Chinese persimmon daily in addition to the basal diet. The cross indicates where 2 grams of persimmon were added to the diet.

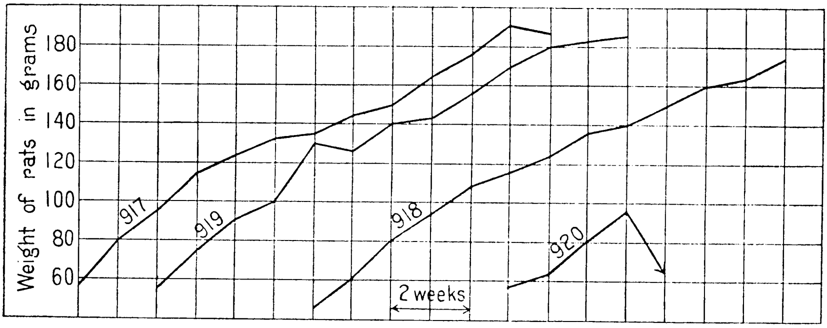

FIG. 3. Rats 917, 918, and 920 received 5 grams of fresh persimmon daily, in addition to the basal diet. They showed good growth and no signs of xerophthalmia. Rat 920 died after a few weeks. A post-mortem examination showed pneumonia.

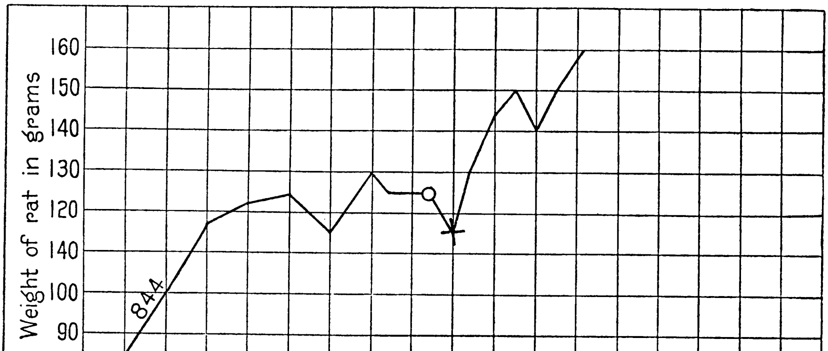

FIG. 4. Rat 844, fed the basal diet, developed a severe case of xerophthalmia. This was cured by deducting 5 per cent of starch and replacing it with 5 per cent of huang hua ts'ai. The cross shows the addition of 5 per cent huang hua ts'ai.

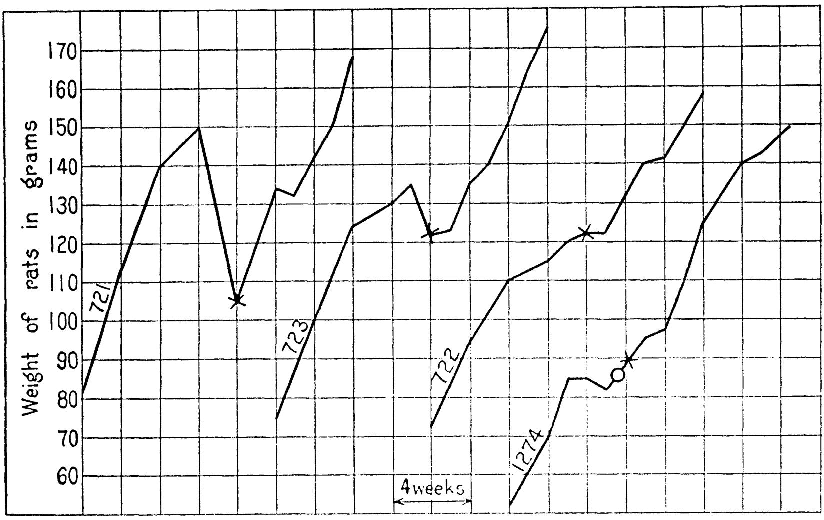

FIG. 5. Rats 721, 722, 723, and 1274, after having received only the basal diet for eight weeks, were given the basal diet with 10 per cent huang hua ts'ai incorporated in it. They all recovered weight and showed excellent growth and physical condition. The cross shows the addition of 10 per cent of huang hua ts'ai.

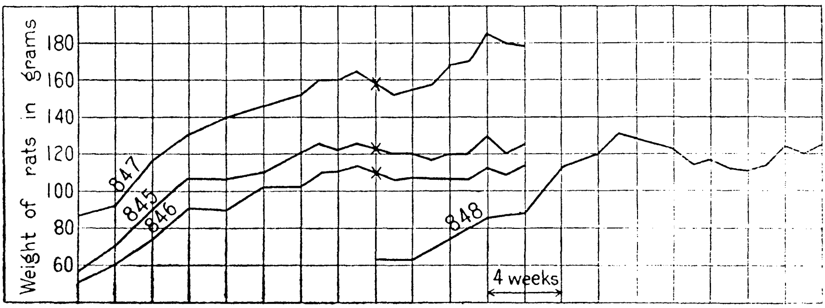

FIG. 6. Rats 845, 846, 847, and 848 were given the basal diet, with 10 per cent of bean curd incorporated in it, for sixteen weeks. They did not develop xerophthalmia, but their growth was subnormal. The percentage of tou fu was raised to 30 without showing much gain in growth.

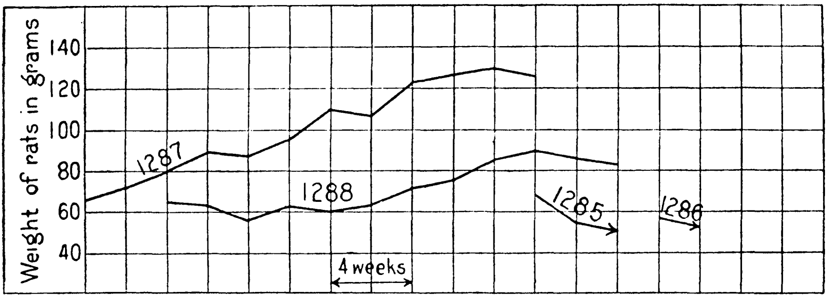

FIG. 7. Rats 1285, 1286, 1287, and 1288 were fed the basal diet with 40 per cent of kan lu incorporated in it. In the beginning of the experiment rats 1285 and 1286 died of pneumonia. Rats 1287 and 1288 did not develop xerophthalmia, but their growth was subnormal.

ILLUSTRATIONS

TEXT FIGURES

[The charts show the identification numbers of the guinea pigs, the rates of growth, and the number of weeks' duration of experimental feeding. The circle on the growth curve indicates severe xerophthalmia. An arrowhead terminating the growth curve indicates the death of the animal in question. Omission of the arrowhead indicates that the animal was still living at the end of the experiment. A cross means the addition of the tested food.]

FIG. 1. Rats 711, 718, 719, and 843 received the basal diet which consisted of purified dry casein (extracted with absolute alcohol three times) 18 per cent. Our standard salt mixture consisted of sodium chloride ($NaCl$), 0.173 gram; magnesium sulphate ($MgSO_4$), 0.266 gram; sodium sulphate (NaH_2PO_4), 0.347 gram; dipotassium phosphate (K_2HPO_4), 0.954 gram; calcium phosphate [$CaH_4(PO_4)_2$], 0.540 gram; ferric citrate, 0.118 gram; and calcium lactate, 1.300 grams. This salt mixture, 4 per cent; dry brewers' yeast (extracted with absolute alcohol three times); purified dry starch prepared from mung bean (extracted with absolute alcohol three times), 68 per cent. All of the rats died, and all showed severe xerophthalmia. This disease developed more rapidly in young rats given the diet than it did in the older ones.

2. Rat 709, fed the basal diet, developed a severe case of xerophthalmia. This was cured by the feeding of 2 grams of fresh Chinese persimmon daily in addition to the basal diet. The cross indicates where 2 grams of persimmon were added to the diet.

3. Rats 917, 918, and 920 received 5 grams of fresh persimmon daily, in addition to the basal diet. They showed good growth and no signs of xerophthalmia. Rat 920 died after a few weeks. A post-mortem examination showed pneumonia.

4. Rat 844, fed the basal diet, developed a severe case of xerophthalmia. This was cured by deducting 5 per cent of starch and replacing it with 5 per cent of huang hua ts'ai. The cross shows the addition of 5 per cent huang hua ts'ai.

5. Rats 721, 722, 723, and 1274, after having received only the basal diet for eight weeks, were given the basal diet with 10 per cent huang hua ts'ai incorporated in it. They all recovered weight and showed excellent growth and physical condition. The cross shows the addition of 10 per cent of huang hua ts'ai.

6. Rats 845, 846, 847, and 848 were given the basal diet, with 10 per cent of bean curd incorporated in it, for sixteen weeks. They did not develop xerophthalmia, but their growth was subnormal. The percentage of tou fu was raised to 30 without showing much gain in growth.

7. Rats 1285, 1286, 1287, and 1288 were fed the basal diet with 40 per cent of kan lu incorporated in it. In the beginning of the experiment rats 1285 and 1286 died of pneumonia. Rats 1287 and 1288 did not develop xerophthalmia, but their growth was subnormal.

RELATIVE CONTENT OF WATER-SOLUBLE VITAMIN B IN THIRTY ORIENTAL FOODS

By HARTLEY EMBREY SHERMAN

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THIRTY-SEVEN TEXT FIGURES

Thirty oriental foods were tested for their relative content of vitamin B. On account of the impossibility of obtaining albino rats when these experiments were started, the initial experiments were done using Chinese white mice and the standard growth curves were previously published.[2] Later the results were checked by feeding some of the same foods to white albino rats. In every case the original results were confirmed, but a slightly higher percentage of the total diet was required to protect the mice from beriberi than was required to protect the rats. The experiments with mice can then be accepted as showing the presence or absence of vitamin B in the foods tested and its relative abundance in these foods.

Only the growth curves showing the minimum percentage of the food tested which protected from beriberi are included in this article.

CONCLUSIONS

1. The following foods are deficient in vitamin B, and do not protect from beriberi at any feeding level: Chinese persimmon (*Diospyros kaki* Linnæus); water chestnut (*Eleocaris tuberosa* Naves); fermented rice, or lao mi (*Oryza sativa* Linnæus); and locust seed (*Robinia pseudoacacia*).

2. Hsiang ch'un, the leaf of *Cedrela sinensis*, contains a poison which causes violent convulsions and death when fed in concentrated form. Wo sun (perhaps a variety of *Lactuca sativa* Linnæus), hao tzu kan (*Chrysanthemum coronarium* Lin-

[1] Most of the laboratory work in these experiments was done at the Peking Union Medical College, with the help of my assistant, Mr. Tsan Ch'ing Wang, to whom much credit is due. The work was completed at the Bureau of Science, Manila.

[2] Embrey, H., China Med. Journ. 35 (1921) 420.

næus), and p'ieh lan (apparently a variety of *Brassica campestris* Linnæus) are not growth producing when fed at high levels, even when added to a complete diet, thus apparently showing the presence of substances that are harmful in very great concentrations.

3. All of the other foods tested—ch'ia ts'ai (*Phaseolus aureus* Roxburgh), huang tou (*Soya max* Linnæus), huang tou ya (sprouts of *Soya max* Linnæus), ch'ing tou (green variety of *Soya max* Linnæus), ch'ing tou ya (the sprouts of the green variety of *Soya max* Linnæus), hung kao liang (red variety of *Sorghum vulgare* Persoon), pai kao liang (white variety of *Sorghum vulgare* Persoon), t' zu ku (*Sagittaria sagittaefolia* Linnæus), wo kua (probably a variety of *Cucurbita pepo* Linnæus), huang hua ts'ai (probably *Hemerocallis flava* Linnæus), chieh ts'ai ying (probably a variety of *Brassica campestris* Linnæus), hu tzu (variety of *Lagenaria vulgaris* Seringe), ssu kua (*Luffa cylindrica* Linnæus), weng ts'ai (a Chinese variety of *Ipomoea reptans* Poiret), upo (a Filipino variety of *Lagenaria vulgaris* Seringe), chico (*Achras sapota* Linnæus), tou fu (bean curd from *Soya max* Linnæus), hsi hulu (probably a variety of *Cucurbita pepo* Linnæus), tung kua (a Chinese variety of *Benincasa hispida* Cogniaux), kan lu (not identified), and papaya (*Carica papaya* Linnæus)—are sources of vitamin B in varying amounts. Chico, hsi hu lu, and tung kua are low in this vitamin.

EXPLANATION OF THE CHARTS

The charts show the identification numbers of the white mice or white rats, the growth curves of the animals used in the experiments, and the number of weeks' duration of experimental feeding.

The numbers above the growth curves are the identification numbers of the animals. The weights of the animals are shown by the figures on the axes of ordinates, and the number of weeks of experimentation is indicated by the numbers on the axes of abscissæ. An arrowhead terminating the growth curve indicates the death of the animal in question. Omission of the arrowhead indicates that the animal was still living at the end of the experiment.

The foods used in the basal diet were prepared in the following way:

The casein was repeatedly dissolved in dilute alkali, and reprecipitated until the ash content was less than 0.7 per cent.

The casein thus obtained was extracted with 80 per cent alcohol, and then with ether, and dried at 100° C.

The starch, made commercially from mung beans, was heated with 0.5 per cent citric acid for four hours at 15 pounds pressure. The dextrinized starch was subsequently washed with 80 per cent alcohol and dried.

Our standard salt mixture consisted of sodium chloride, 0.173 gram; dipotassium hydrogen phosphate, 0.954 gram; magnesium sulphate, 0.266 gram; monosodium phosphate, 0.347 gram; monocalcium phosphate, 0.540 gram; ferric citrate, 0.118 gram; and calcium lactate, 1.300 grams.

Butter was melted below 45° C., and the clear liquid was decanted and centrifuged an hour. This butter fat was used as the source of fat-soluble A.

The foods investigated for vitamin B content, unless otherwise stated, were cooked forty minutes in an autoclave at 15 pounds pressure, and dried in a current of air below 60° C. The food under investigation was introduced into the basal diet by diminishing the amount of starch by the same percentage as that of the food used. The ingredients of the diets were ground so fine that the animals were unable to separate them.

TABLE 1.—*Foods fed to Chinese mice.*

Test No. and description or English name of food tested.	Local name in Peking dialect and, when possible, also in Tagalog.	Scientific name.	Percentage of the food tested necessary in a beriberi diet for normal growth and reproduction.	Remarks.
1. Sprout of the mung bean with root removed.	Ch'ia ts'ai	*Phaseolus aureus* Roxburg	Fifteen per cent.	Plentiful source of vitamin B.
2. Heads of the mung bean sprouts.	do	do	do	This test was made to see if the vitamin was concentrated in one part of the vegetable.
3. Yellow soy bean	Huang tou	*Soya max* Linnæus	do	Plentiful source of vitamin B.
4. Yellow soy-bean sprout	Huang tou ya	do	Normal growth, 15; normal reproduction, 20.	Do.
5. Green soy bean	Ch'ing tou	do	Fifteen per cent.	Do.
6. Green soy-bean sprout	Ch'ing tou ya	do	Normal growth, 15; normal reproduction, 20.	Do.
7. Red variety	Hung kaoliang	*Sorghum vulgare* Persoon	Almost normal growth, 30	This is commonly used as a grain in North China in place of rice.
8. White variety	Pai kaoliang	do	Normal growth, 25; normal reproduction, 35.	Used as a rice substitute in North China.
9. No English equivalent.	T'zu ku	*Sagittaria sagittaefolia* Linnæus.	Twenty-five per cent.	Plentiful source of vitamin B.
10. A crook-necked gourd, often called "Japanese gourd."	Wo kua	Probably a variety of *Cucurbita pepo* Linnæus.	Normal growth at 50; no reproduction at that level.	Low in vitamin B.
11. A pot herb with a yellow flower.	Huang hua ts'ai	Probably *Hemerocallis flava* Linnæus.	Normal growth, 30; no reproduction at that level.	Moderate amount of vitamin B.
12. A green leaf vegetable.	Chieh ts'ai ying	Probably *Brassica campestris* Linnæus.	Normal growth, 30; reproduction at that level subnormal.	Do.
13. An edible gourd	Hu tzu (Chinese); similar to the upo (Filipino).	Variety of *Lagenaria vulgaris* Seringe.	Normal growth at 40; reproduction subnormal at that level.	Do.

14. Edible tuber called by Americans "water chestnut."	Pi ch'i (Chinese); Apulid Tsina (Filipino).	*Eleocaris tuberosa* Naves	Seventy-three per cent of the total diet did not protect from beriberi.	Deficient in vitamin B.
15. Locust seed	Huai tzu	*Robinia pseudoacacia*	With 70 per cent of the total diet, all died from beriberi.	In severe famines this is often the main food. Deficient in vitamin B.
16. Tribute Manchu rice, which fermented and was sold as a food delicacy. It is called "old rice."	Lao mi	*Oryza sativa* Linnæus	At 73 per cent of the total diet, all died of beriberi.	Deficient in vitamin B.
17. Chinese persimmon	Shih tzu	*Diospyros kaki* Linnæus	When fed ad libitum, all died from beriberi.	Do.
18. Leaf of a tree in North China used as a vegetable in the spring.	Hsiang ch'un	Probably *Cedrela sinensis*	Impossible to test for vitamin B, on account of a toxic substance present in the food.	Even when added to a complete diet, a toxin in the food caused convulsions and death.
19. A lettuce root	Wo sun	Perhaps a variety of *Lactuca sativa* Linnæus. It has also some characteristics of a *Brassica*.	At 60 per cent level mice lose weight and live only from six to eight weeks.	Very low in vitamin B.
20. A long, mottled, green vegetable with lengthwise ridges.	Ssu kua (Chinese); Kastila (Filipino).	*Luffa cylindrica* (Linnæus) M. Roemer.	With 50 per cent of the diet, stable weight was maintained. Growth and reproduction were subnormal.	Low in vitamin B.

TABLE 2.—*Foods fed to albino rats.*

Test No. and description or English name of food tested.	Local name in Peking dialect and, when possible, also in Tagalog.	Scientific name.	Percentage of the food tested necessary in a beriberi diet for normal growth and reproduction.	Remarks.
21. Repetition of test 18, using rats instead of mice.	Hsiang ch'un	Probably *Cedrela sinensis*	No result on vitamin B, on account of the presence of a toxin.	Result in test 18 confirmed. A toxic substance caused convulsions and death.
22. Repetition of test 19, using rats instead of mice.	Wo sun	Probably *Lactuca sativa* Linnæus.	At 60 per cent level animals all lost weight.	At high concentrations the animals lost weight and disliked their food.
23. An edible green leaf	Weng ts'ai (Chinese); kankang (Filipino).	Variety of *Ipomoea reptans* Poir.	Forty per cent protected from beriberi fourteen weeks. Growth subnormal.	Moderate amount of vitamin B present.
24. A bottle gourd	Upo (Filipino), similar to Chinese hu tzu.	Variety of *Lagenaria vulgaris* Seringe.	Twenty-five per cent gave almost normal growth. Reproduction almost normal.	Plentiful source of vitamin B.
25. A fruit called chico in English.	Chico (Filipino)	*Achras sapota* Linnæus	Almost normal growth, 55	Vitamin B content low.
26. Papaya	Papaya (Filipino)	*Carica papaya* Linnæus	Normal growth, 25; reproduction, 35.	Source of vitamin B.
27. Soy-bean curd. Proteins precipitated from the yellow soy bean.	Tou fou	*Soya max* Linnæus	Normal growth and reproduction, 20.	Plentiful source of vitamin B.
28. A vegetable marrow	Hsi hu lu	Probably a variety of *Cucurbita pepo* Linnæus.	At 60 per cent weight is maintained. Growth and reproduction subnormal.	Very low in vitamin B.
29. An edible green leaf	Hao tzu kan (Chinese); Tanñgu (Filipino).	*Chrysanthemum coronarium* Linnæus.	At 60 per cent only one animal survived.	When added to a complete diet at high concentrations growth was subnormal.

30. A kohl-rabi	P'ieh lan	Apparently a variety of *Brassica campestris* Linnæus.	At 40 per cent level animals lived four months. At 60 per cent level rats lived three to six weeks.	Animals died from beriberi at low levels of feeding. At higher levels the food did not agree with the animals.
31. A melon-shaped vegetable	Tung kua (Chinese); kondol	*Benincasa hispida* Cogniaux	Sixty per cent protected from beriberi for two months, but growth was subnormal.	Very low in vitamin B.
32. Not identified	Kan lu (Pekingese)	Not identified; probably *Stachys sieboldi* Miquel.	Ten per cent gave normal growth.	Plentiful source of vitamin B.

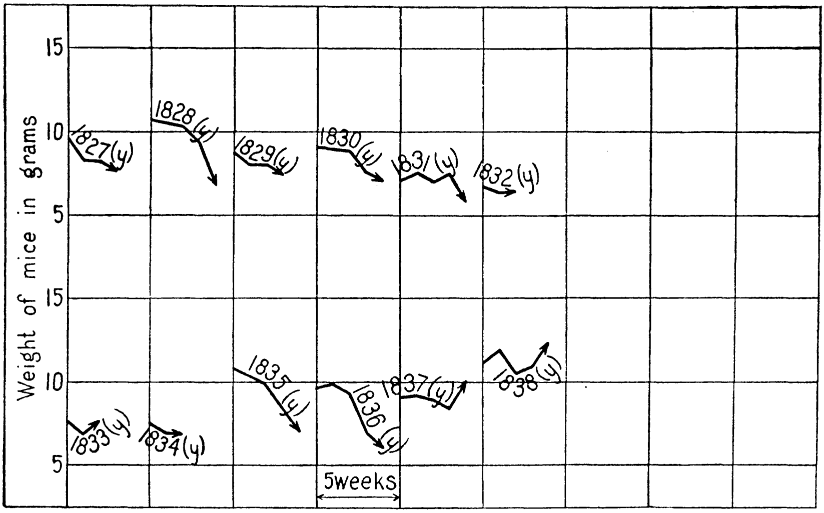

FIG. 1. These mice received the following basal diet: Casein, 18 per cent; a mixture of salts, 4 per cent; starch, 73 per cent; butter, 5 per cent.

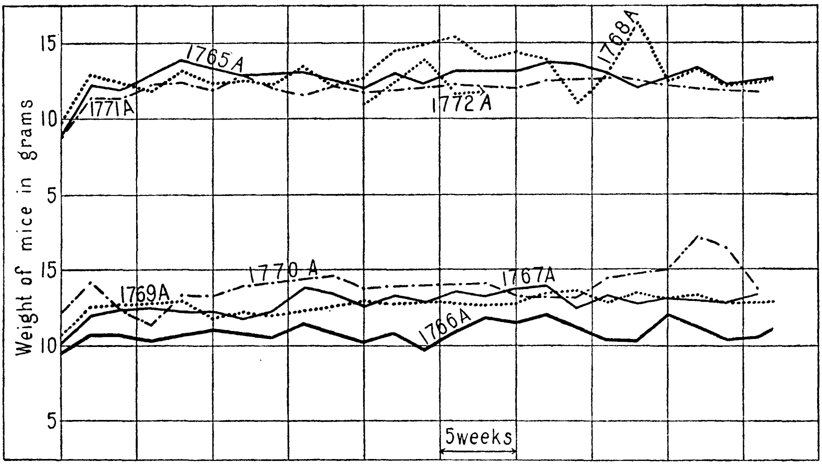

FIG. 2. These mice received the basal diet described under fig. 1 with 15 per cent of ch'ia ts'ai incorporated in the diet by substituting the ch'ia ts'ai for 15 per cent of starch. All of the foods tested were incorporated in the basal diet in the same manner by substitution for an equivalent amount of starch. The second generation on the basal diet and 15 per cent of ch'ia ts'ai showed excellent growth.

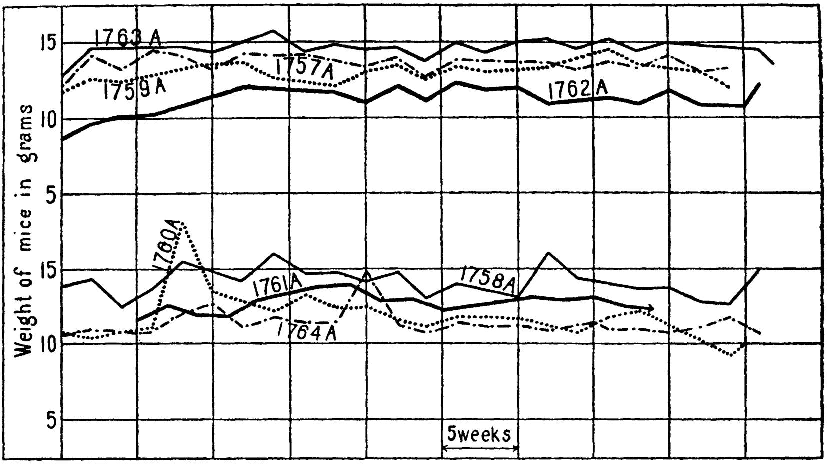

FIG. 3. These mice received the basal diet with 15 per cent of the heads of mung-bean sprouts incorporated in it. This diet was given in order to determine whether the vitamin B content of the sprouts was concentrated more in one part of the plant than in another. The second generation on diet showed excellent growth.

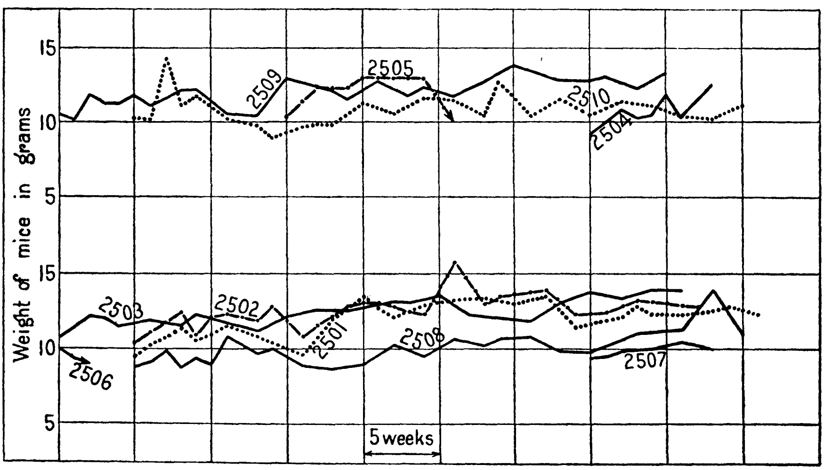

FIG. 4. These mice received 15 per cent of yellow soy bean incorporated in the basal diet. The second generation on this diet were having good growth when the experiment was terminated.

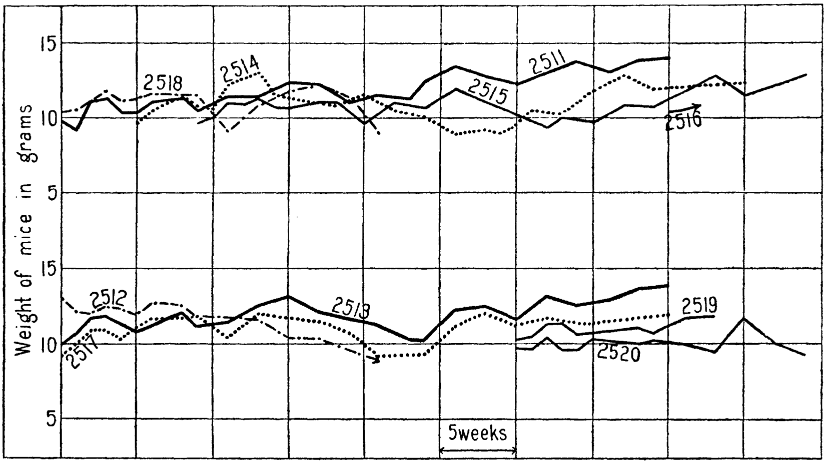

FIG. 5. These mice received 15 per cent of yellow soy-bean sprout incorporated in the basal diet. They showed fair growth and presented no signs of beriberi. Reproduction and growth of the second generation were, however, subnormal when only 15 per cent of yellow soy-bean sprout was used.

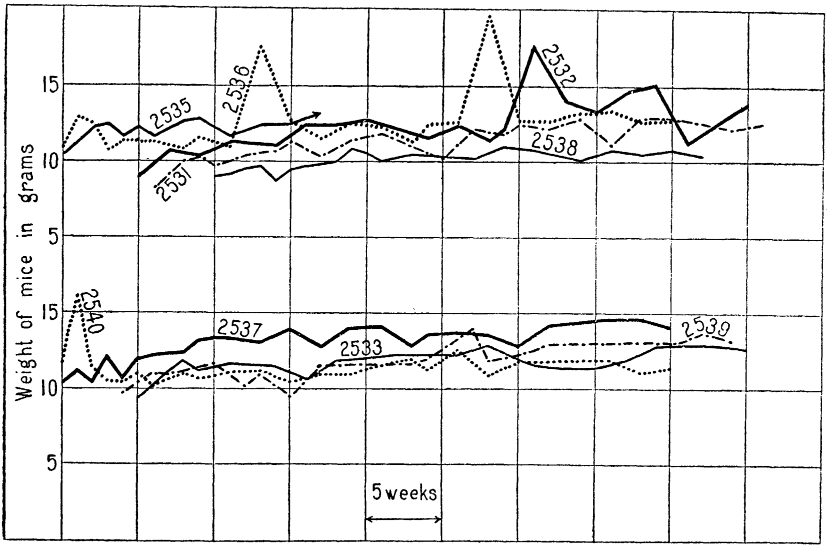

FIG. 6. These mice received 20 per cent of yellow soy-bean sprout incorporated in the diet. They had normal growth and reproduction.

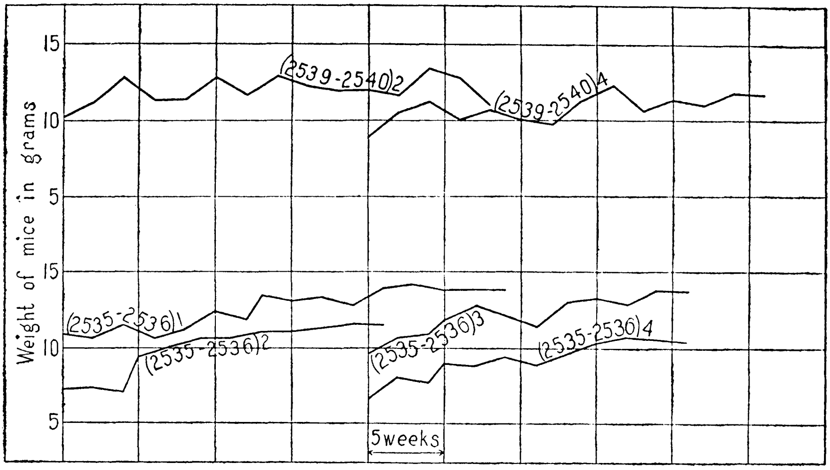

FIG. 7. These mice were the second generation on a diet of 20 per cent yellow soy bean. They all had normal growth.

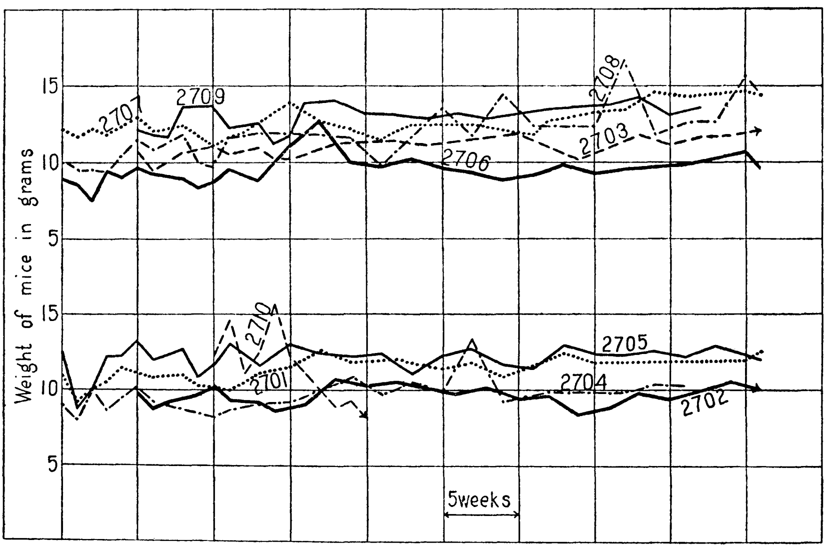

FIG. 8. These mice received 15 per cent of green soy bean incorporated in the basal diet. They showed good growth in the first generation.

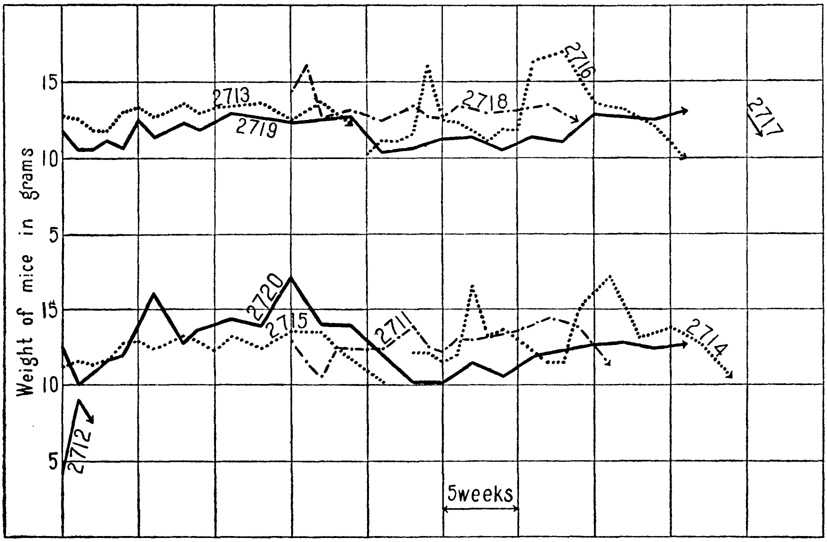

FIG. 9. These mice received 15 per cent of sprouted green soy bean incorporated in the basal diet. The first generation almost normal growth, but only two of the second generation survived the period of lactation. When 20 per cent of sprouted green soy bean was given, both the first and the second generation grew normally.

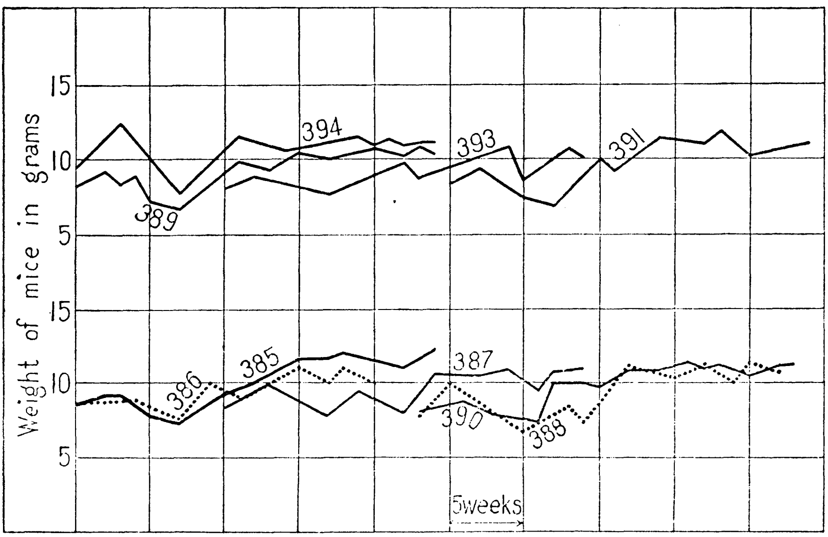

FIG. 10. These mice received 30 per cent of the red variety of kaoliang. Growth was normal, but none of the second generation lived.

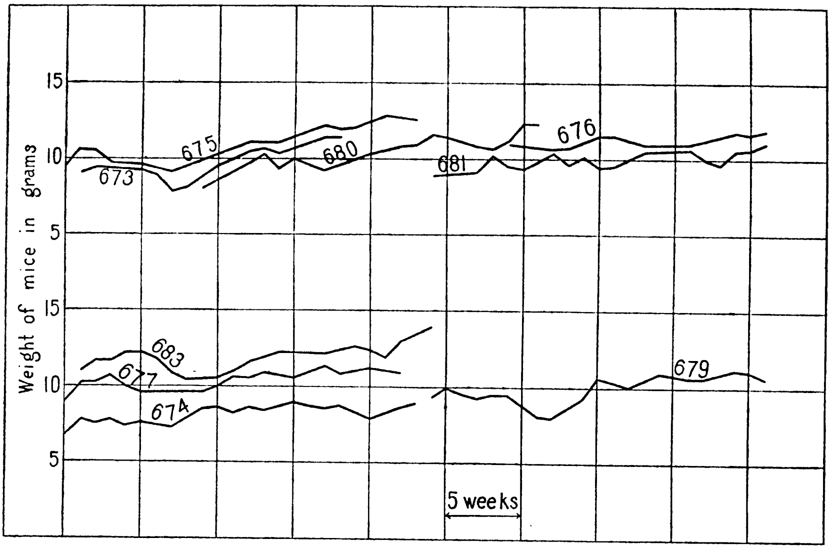

FIG. 11. These mice received 25 per cent of the white variety of kaoliang. Two of the second and three of the third generation lived on this diet. The rate of reproduction was subnormal, however.

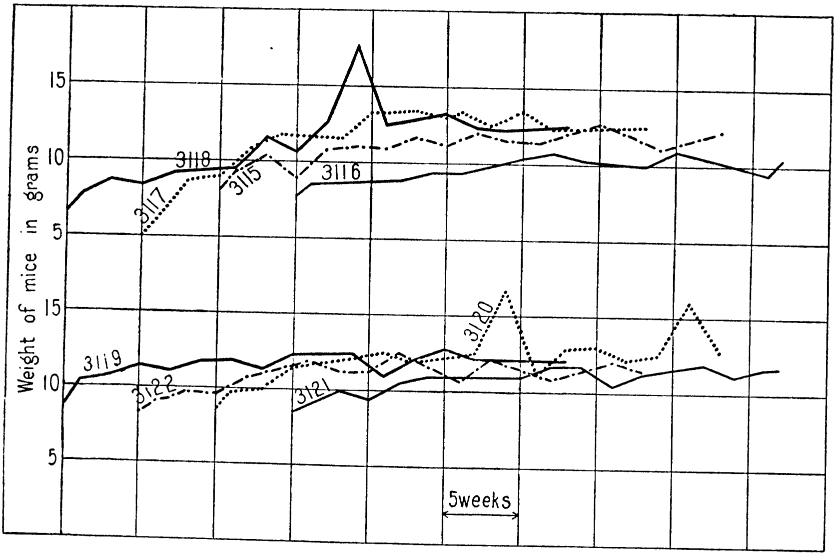

FIG. 12. These mice received 25 per cent of t'zu ku incorporated in the basal diet. They were protected from beriberi and had normal growth. Four of the second generation lived.

FIG. 13. These mice received 50 per cent of wo kua incorporated in the basal diet. All of the mice were protected from beriberi during the time of the experiment, and the growth of the first generation was almost normal. There was no reproduction on this diet.

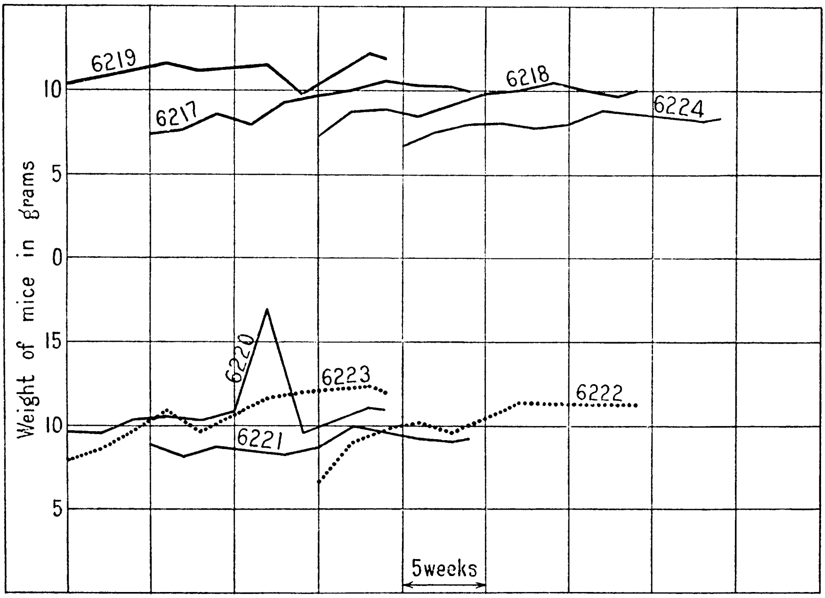

FIG. 14. These mice received 30 per cent of huang kua ts'ai and the basal diet. Growth of the first generation was normal. None of the young lived.

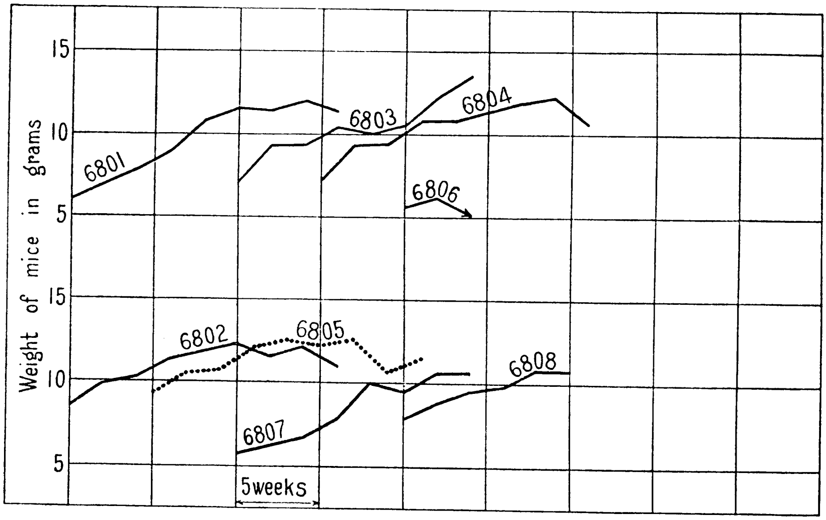

FIG. 15. These mice received 30 per cent of chieh ts'ai ying and the basal diet. The growth of the first generation was almost normal, but the rate of reproduction was subnormal.

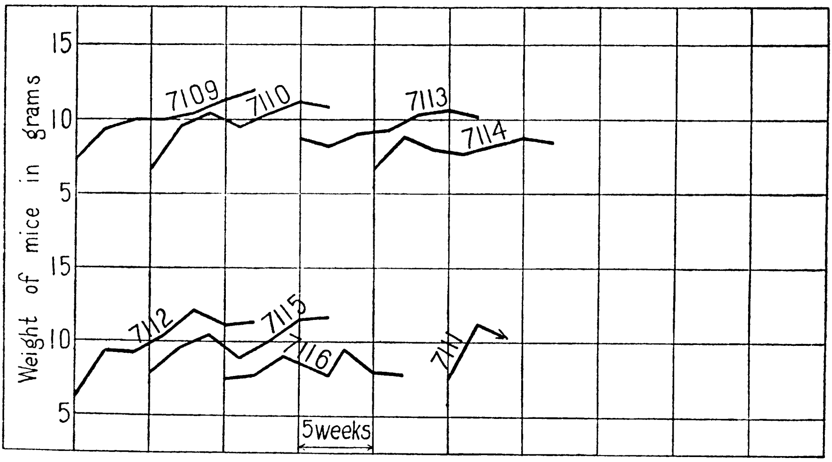

FIG. 16. These mice were given 40 per cent of hu tzu and the basal diet. The growth of the first generation was almost normal. Reproduction was subnormal.

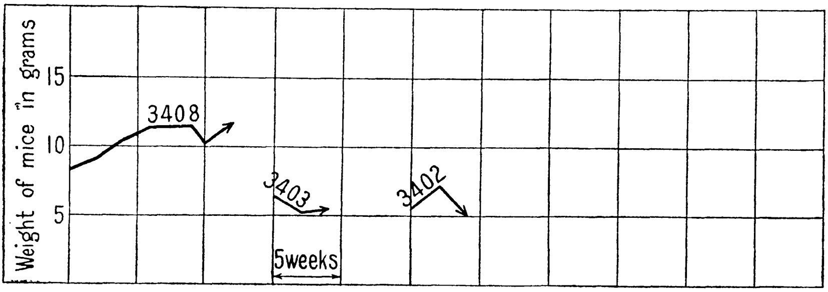

FIG. 17. These mice were given the basal diet with 73 per cent of pi ch'i incorporated in it. They all died of beriberi, thus proving that pi ch'i is deficient in vitamin B. Only one mouse lived longer than three weeks.

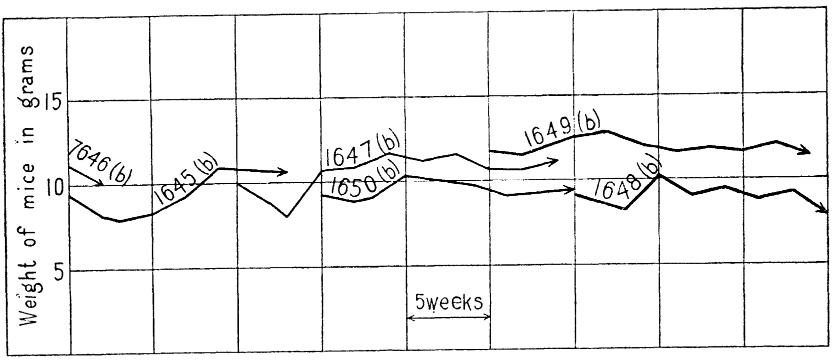

FIG. 18. These mice were given the basal diet with 70 per cent of locust seed incorporated in it. They lived from twelve to twenty weeks, but finally died of beriberi, thus proving that, while locust seed contain relatively a little more of vitamin B than does pi ch'i, both of these foods are deficient in this vitamin.

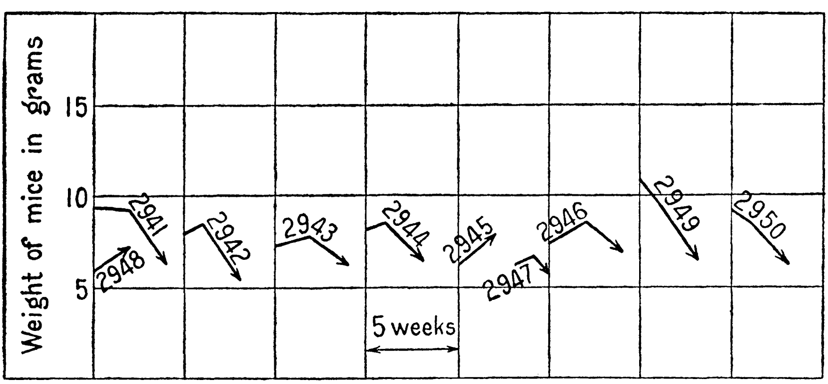

FIG. 19. These mice were given 73 per cent of lao mi incorporated in the basal diet. All of them died from beriberi in from two of three weeks.

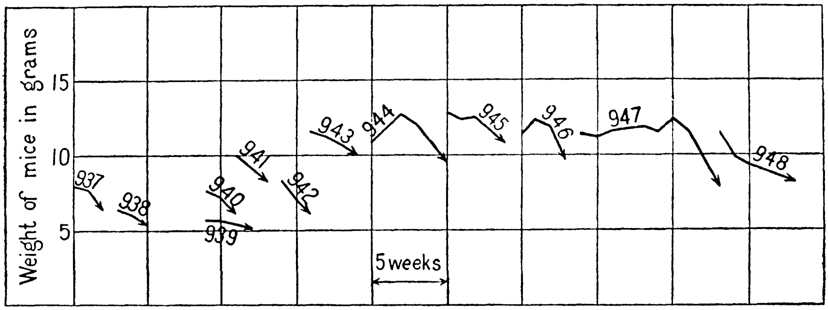

FIG. 20. These mice received the basal diet and fresh persimmon ad libitum. They all died from beriberi in from two to seven weeks, thus proving that persimmon is deficient in vitamin B.

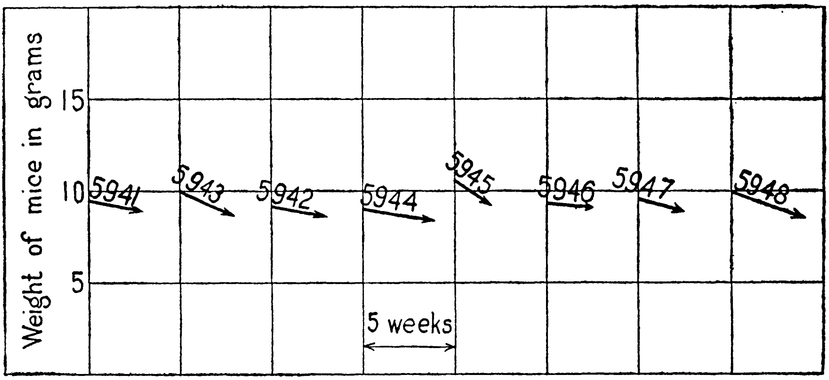

FIG. 21. These mice received the basal diet with 60 per cent of hsiang ch'un incorporated in it. There is evidently a toxic principle in hsiang ch'un which causes convulsions and death after a couple of weeks of a diet containing a high level of hsiang ch'un. The mice died from the effects of a poison, and not from the usual beriberi symptoms. This toxin should be investigated further.

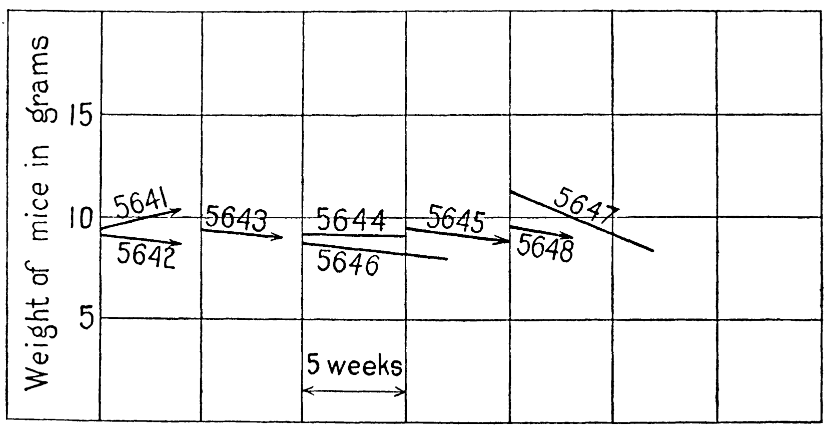

FIG. 22. These mice received 60 per cent of wo sun in the basal diet. They lost weight and lived only from six to eight weeks.

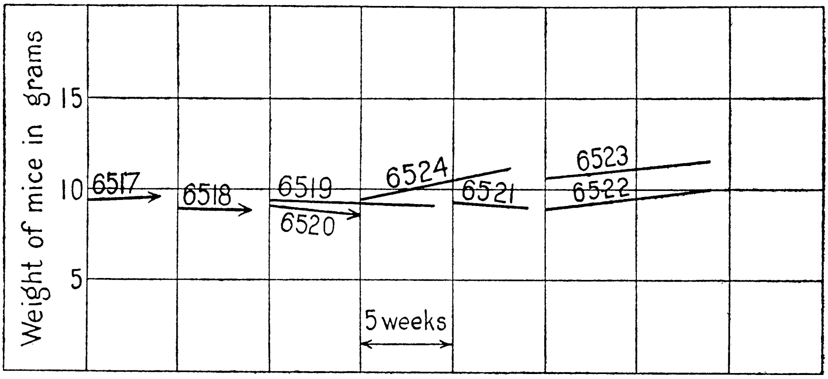

FIG. 23. These mice received 50 per cent of ssu kua incorporated in the basal diet. Four of the mice were living after eight weeks on this diet. Their growth was subnormal. The results show the presence of vitamin B, but in relatively small amounts.

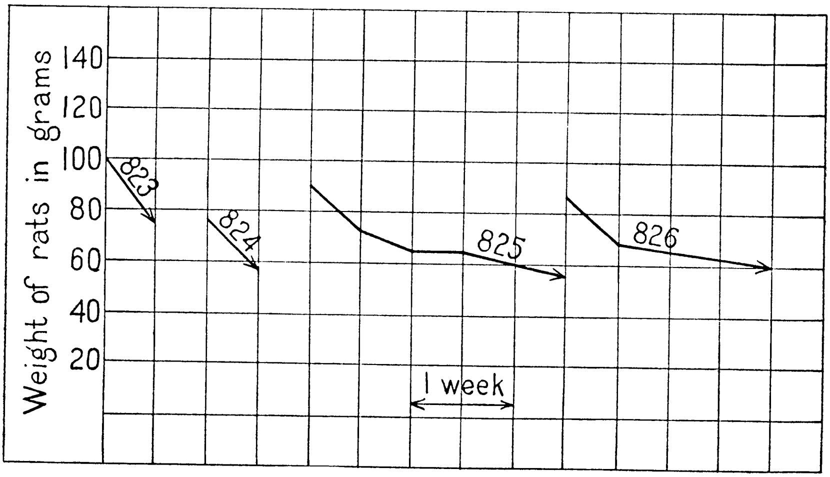

FIG. 24. A diet of hsiang ch'un, 63 per cent; casein, 18 per cent; a mixture of salts, 4 per cent; butter, 5 per cent; and yeast, 10 per cent was given to albino rats. These rats died after having convulsions, thus confirming the results obtained with mice, and proving the toxic effect of hsiang ch'un even with a diet affording ample vitamin B.

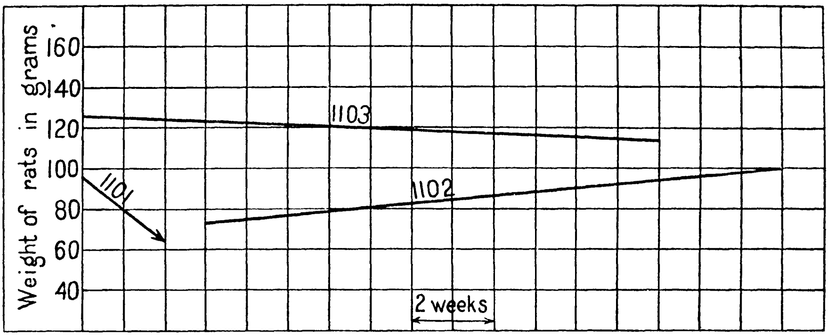

FIG. 25. These albino rats received 40 per cent of weng ts'ai incorporated in the basal diet. This amount of food supplied enough vitamin B to protect the rats from beriberi, but not enough to insure normal growth and reproduction.

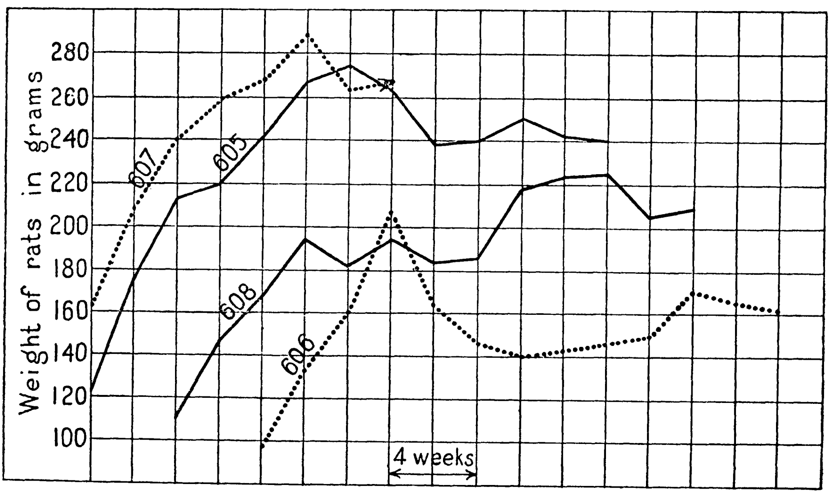

FIG. 26. Twenty-five per cent of Philippine upo in the basal diet gave good growth and a fair rate of reproduction in the case of three albino rats. This result proves that upo is a plentiful source of vitamin B.

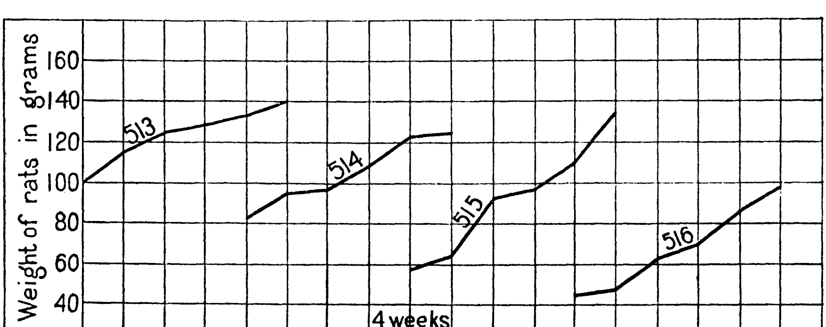

FIG. 27. Fifty-five per cent of chico protected four albino rats from beriberi for a period of ten weeks.

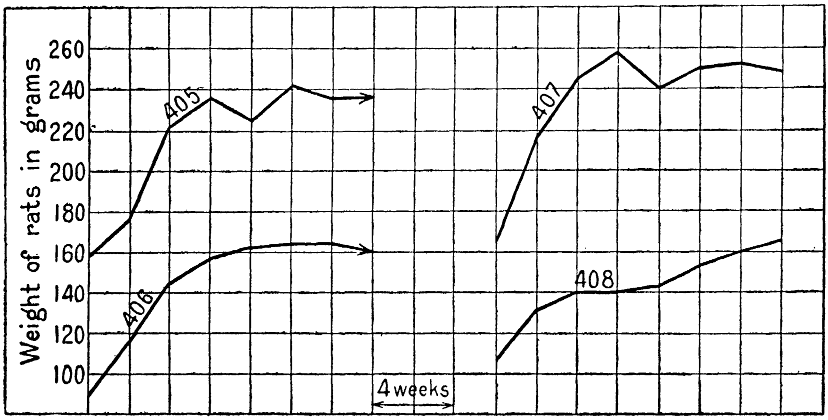

FIG. 28. Twenty-five per cent of papaya protected two albino rats from beriberi for a period of ten weeks, but growth was not normal.

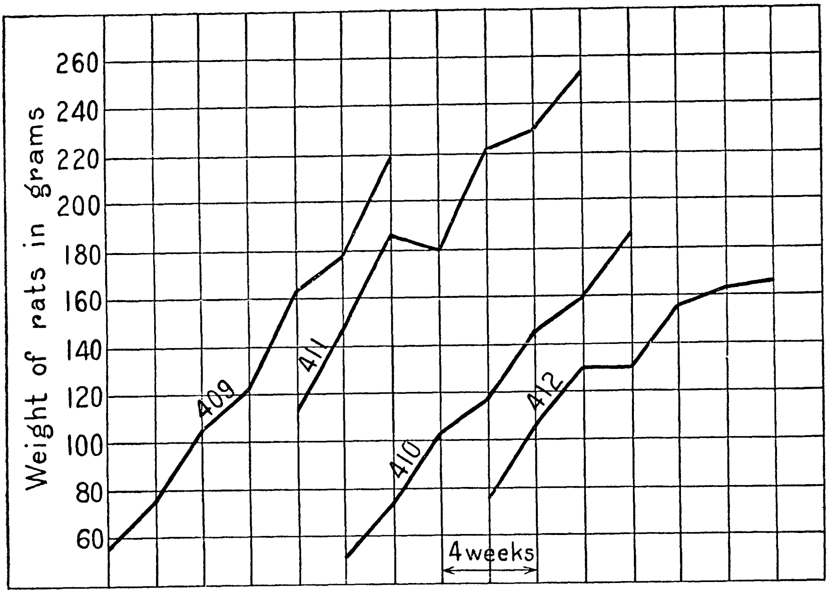

FIG. 29. Thirty-five per cent of papaya in the basal diet gave excellent growth.

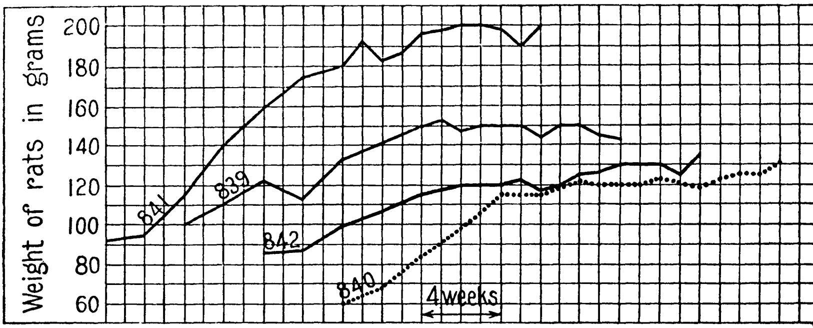

FIG. 30. Twenty per cent of commercial bean curd made from yellow soy bean protected four albino rats from beriberi for twenty-two weeks. This result shows that most of the vitamin B content of the original yellow soy bean appears in the commercial bean curd. This fact should be of practical value, since bean curd and rice often constitute the entire meal of poor Chinese.

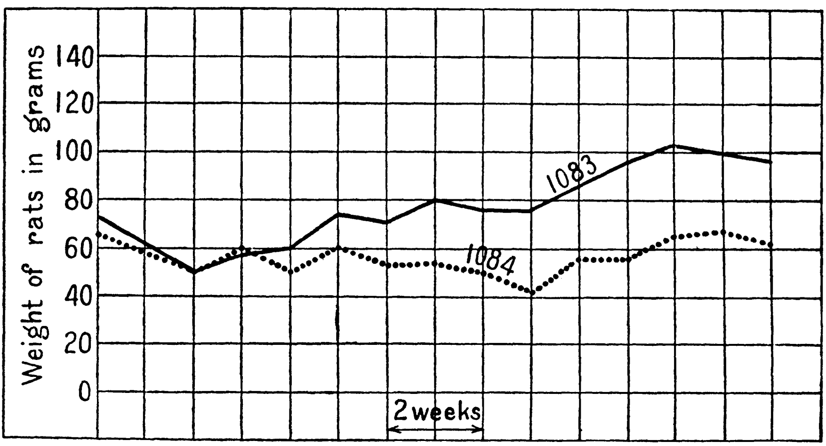

FIG. 31. Sixty per cent of hsi hu lu in the basal diet protected two albino rats from beriberi for fourteen weeks. This result proves the presence of vitamin B in this food, but only in small amount.

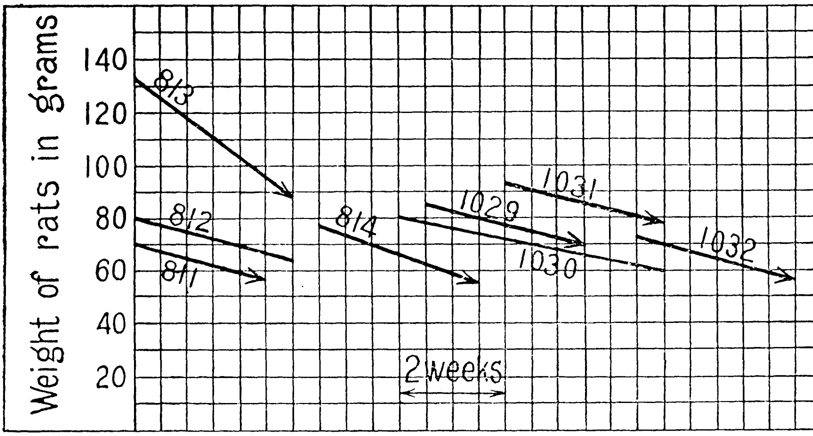

FIG. 32. Sixty per cent of hao tzu kan in the diet did not protect albino rats from beriberi. The high concentration of this food in the diet did not seem to agree with the rats. They did not seem to have normal appetites.

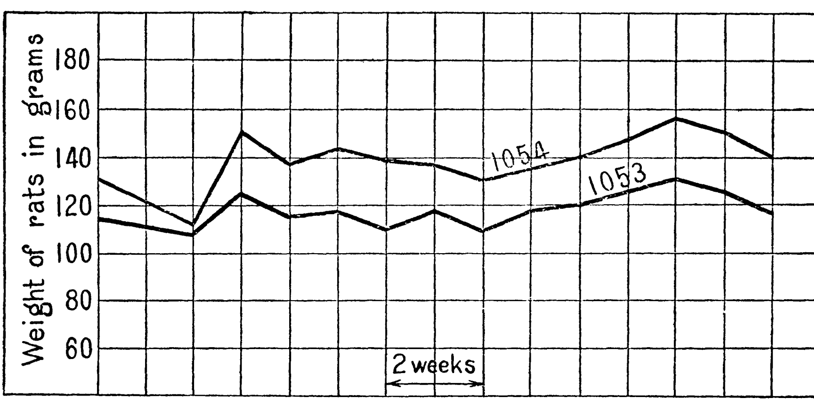

FIG. 33. Forty per cent of p'ieh lan in the basal diet contained enough vitamin B to protect two albino rats from beriberi for fourteen weeks. The rate of growth was subnormal, however.

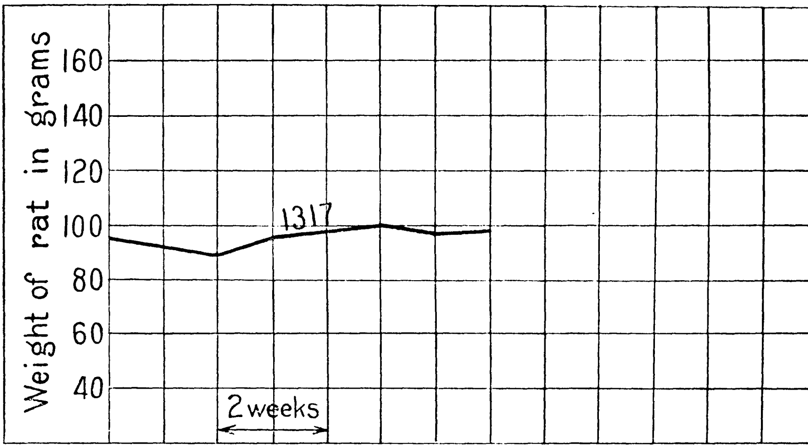

FIG. 34. This rat received 60 per cent of p'ieh lan and 15 per cent of yeast incorporated in the basal diet by eliminating the starch. The growth remained subnormal, thus proving that p'ieh lan when given in great concentration in an otherwise complete diet has a depressing effect on growth.

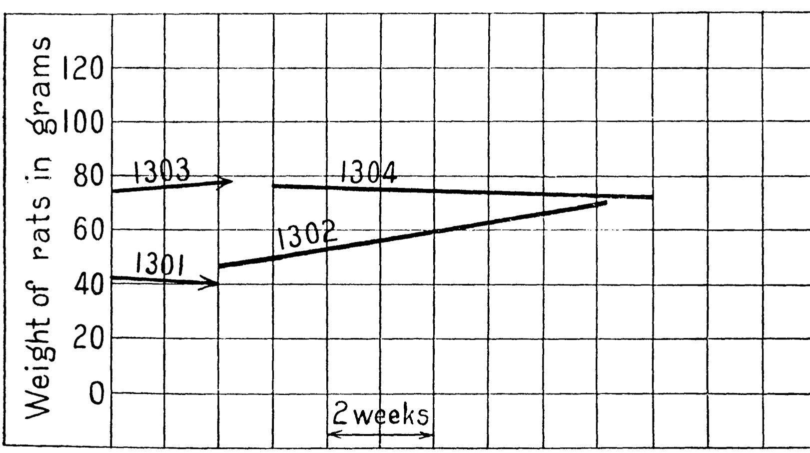

FIG. 35. When 73 per cent of tung kua was incorporated in the basal diet, two of the rats died.

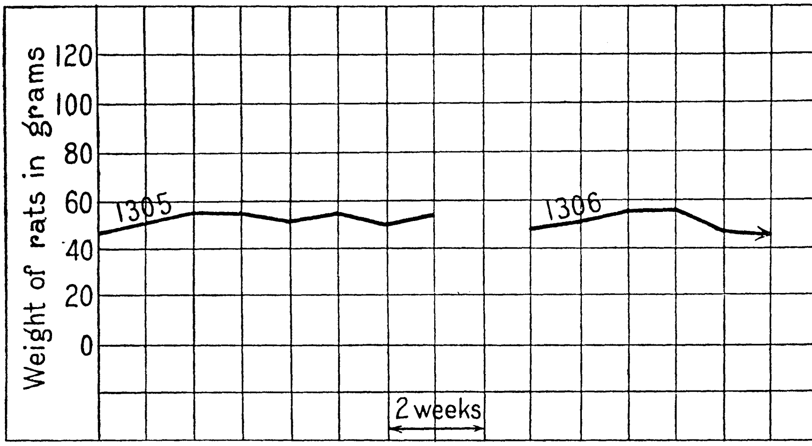

FIG. 36. Fifty-eight per cent of tung kua and 15 per cent of yeast were incorporated in the basal diet of omitting the starch. One rat died and the other rat on this diet showed subnormal growth. These results show that tung kua apparently contains something that hinders the growth when it is given in great concentrations, even with complete diet. At low levels of feeding the rats die of beriberi.

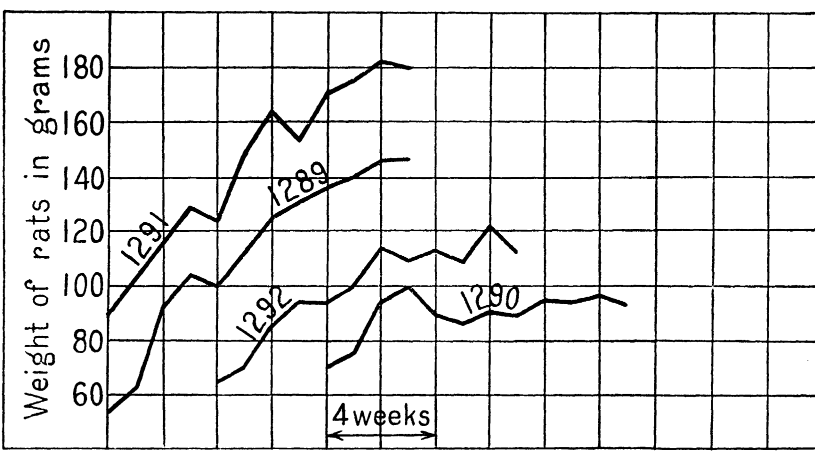

FIG. 37. Ten per cent of kan lu incorporated in the basal diet gave a very good growth. This food is, therefore, an abundant source of vitamin B.

ILLUSTRATIONS

TEXT FIGURES

GROWTH CURVES OF MICE

FIG. 1. These mice received the following basal diet: Casein, 18 per cent; a mixture of salts, 4 per cent; starch, 73 per cent; butter, 5 per cent. All of the mice had beriberi.

2. These mice received the basal diet described under fig. 1 with 15 per cent of ch'ia ts'ai incorporated in the diet by substituting the ch'ia ts'ai for 15 per cent of starch. All of the foods tested were incorporated in the basal diet in the same manner by substitution for an equivalent amount of starch. The second generation on the basal diet and 15 per cent of ch'ia ts'ai showed excellent growth.

3. These mice received the basal diet with 15 per cent of the heads of mung-bean sprouts incorporated in it. This diet was given in order to determine whether the vitamin B content of the sprouts was concentrated more in one part of the plant than in another. The second generation on this diet showed excellent growth.

4. These mice received 15 per cent of yellow soy bean incorporated in the basal diet. The second generation on this diet were having good growth when the experiment was terminated.

5. These mice received 15 per cent of yellow soy-bean sprout incorporated in the basal diet. They showed fair growth and presented no signs of beriberi. Reproduction and growth of the second generation were, however, subnormal when only 15 per cent of yellow soy-bean sprout was used.

6. These mice received 20 per cent of yellow soy-bean sprout incorporated in the diet. They had normal growth and reproduction.

7. These mice were the second generation on a diet of 20 per cent yellow soy bean. They all had normal growth.

8. These mice received 15 per cent of green soy bean incorporated in the basal diet. They showed good growth in the first generation.

9. These mice received 15 per cent of sprouted green soy bean incorporated in the basal diet. The first generation showed almost normal growth, but only two of the second generation survived the period of lactation. When 20 per cent of sprouted green soy bean was given, both the first and the second generations grew normally.

FIG. 10. These mice received 30 per cent of the red variety of kaoliang. Growth was normal, but none of the second generation lived.

11. These mice received 25 per cent of the white variety of kaoliang. Two of the second and three of the third generation lived on this diet. The rate of reproduction was subnormal, however.

12. These mice received 25 per cent of t'zu ku incorporated in the basal diet. They were protected from beriberi and had normal growth. Four of the second generation lived.

13. These mice received 50 per cent of wo kua incorporated in the basal diet. All of the mice were protected from beriberi during the time of the experiment, and the growth of the first generation was almost normal. There was no reproduction on this diet.

14. These mice received 30 per cent of huang hua ts'ai and the basal diet. Growth of the first generation was normal. None of the young lived.

15. These mice received 30 per cent of chieh ts'ai ying and the basal diet. The growth of the first generation was almost normal, but the rate of reproduction was subnormal.

16. These mice were given 40 per cent of hu tzu and the basal diet. The growth of the first generation was almost normal. Reproduction was subnormal.

17. These mice were given the basal diet with 73 per cent of pi ch'i incorporated in it. They all died of beriberi, thus proving that pi ch'i is deficient in vitamin B. Only one mouse lived longer than three weeks.

18. These mice were given the basal diet with 70 per cent of locust seed incorporated in it. They lived from twelve to twenty weeks, but finally died of beriberi, thus proving that while locust seed contains relatively a little more of vitamin B than does pi ch'i both of these foods are deficient in this vitamin.

19. These mice were given 73 per cent of lao mi incorporated in the basal diet. All of them died from beriberi in from two to three weeks.

20. These mice received the basal diet and fresh persimmon ad libitum. They all died from beriberi in from two to seven weeks, thus proving that persimmon is deficient in vitamin B.

21. These mice received the basal diet with 60 per cent of hsiang ch'un incorporated in it. There is evidently a toxic principle in hsiang ch'un which causes convulsions and death after a couple of weeks of a diet containing a high level of hsiang ch'un. The mice died from the effects of a poison, and not from the usual beriberi symptoms. This toxin should be investigated further.

22. These mice received 60 per cent of wo sun in the basal diet. They lost weight and lived only from six to eight weeks.

FIG. 23. These mice received 50 per cent of ssu kua incorporated in the basal diet. Four of the mice were living after eight weeks on this diet. Their growth was subnormal. The results show the presence of vitamin B, but in relatively small amounts.

GROWTH CURVES OF RATS

FIG. 24. A diet of hsiang ch'un, 63 per cent; casein, 18 per cent; a mixture of salts, 4 per cent; butter, 5 per cent; and yeast, 10 per cent was given to albino rats. These rats died after having convulsions, thus confirming the results obtained with mice, and proving the toxic effect of hsiang ch'un even with a diet affording ample vitamin B.

25. These albino rats received 40 per cent of weng ts'ai incorporated in the basal diet. This amount of food supplied enough vitamin B to protect the rats from beriberi, but not enough to insure normal growth and reproduction.

26. Twenty-five per cent of Philippine upo in the basal diet gave good growth and a fair rate of reproduction in the case of three albino rats. This result proves that upo is a plentiful source of vitamin B.

27. Fifty-five per cent of chico protected four albino rats from beriberi for a period of ten weeks.

28. Twenty-five per cent of papaya protected two albino rats from beriberi for a period of ten weeks, but growth was not normal.

29. Thirty-five per cent of papaya in the basal diet gave excellent growth.

30. Twenty per cent of commercial bean curd made from yellow soy bean protected four albino rats from beriberi for twenty-two weeks. This result shows that most of the vitamin B content of the original yellow soy bean appears in the commercial bean curd. This fact should be of practical value, since bean curd and rice often constitute the entire meal of poor Chinese.

31. Sixty per cent of hsi hu lu in the basal diet protected two albino rats from beriberi for fourteen weeks. This result proves the presence of vitamin B in this food, but only in small amount.

32. Sixty per cent of hao tzu kan in the diet did not protect albino rats from beriberi. The high concentration of this food in the diet did not seem to agree with the rats. They did not appear to have normal appetites.

33. Forty per cent of p'ieh lan in the basal diet contained enough vitamin B to protect two albino rats from beriberi for fourteen weeks. The rate of growth was subnormal, however.

34. This rat received 60 per cent of p'ieh lan and 15 per cent of yeast incorporated in the basal diet by eliminating the starch. The growth remained subnormal, thus proving that p'ieh lan when given in great concentration in an otherwise complete diet has a depressing effect on growth.

FIG. 35. When 73 per cent of tung kua was incorporated in the basal diet, two of the rats died.

36. Fifty-eight per cent of tung kua and 15 per cent of yeast were incorporated in the basal diet by omitting the starch. One rat died, and the other rat on this diet showed subnormal growth. These results show that tung kua apparently contains something that hinders the growth when it is given in great concentrations, even with a complete diet. At low levels of feeding the rats die of beriberi. On account of lack of time we were unable to check this work, or to find out whether this food had become contaminated in any way. We hope to repeat this work later and to continue our investigation along these lines.

37. Ten per cent of kan lu incorporated in the basal diet gave very good growth. This food is, therefore, an abundant source of vitamin B.

RELATIVE WATER-SOLUBLE VITAMIN C CONTENT OF NINE ORIENTAL FRUITS AND VEGETABLES

By HARTLEY EMBREY SHERMAN

Of the Laboratories of Food Chemistry, Peking Union Medical College Peking, China, and the Bureau of Science, Manila[1]

TEN TEXT FIGURES

Many infants in the Orient are fed only preserved, condensed, or powdered milk. With the object of discovering what native foods might be used to protect children in the Orient from scurvy, a control basal diet lacking vitamin C[2] was fed to guinea pigs; many oriental vegetables and fruits were thus tested. Some of the results have already been published.[3] Table 1 gives the results with nine foods.

In each case the stated amount of the fresh food was fed by hand to the guinea pigs before the basal diet (ad libitum) was given. In some cases the fresh food was given in its natural state, and in other cases the freshly expressed juice was used—according to the nature of the food and the ease of feeding. The animals that died during the experiment were examined post mortem for the clinical symptoms of scurvy in guinea pigs.[4]

CONCLUSIONS

Pomegranate, Chinese cabbage, and hsiang ts'ai (*Coriandrum sativum* Linnæus) are rich in vitamin C.

Hung kuo, pich'i (*Eleocharis tuberosa* Naves), and ou (*Nelumbium speciosum* Willdenow) are good sources of vitamin C.

P'ieh lan (probably *Brassica oleracea caulorapa*) contains only a small amount of vitamin C.

Hung tsao (probably *Polygonum orientale* Linnæus) and wo sun (a variety of *Lactuca sativa* Linnæus) are very low in vitamin C.

[1] Most of the laboratory work described in this experiment was done at the Peking Union Medical College, with the aid of my assistant, Mr. Tsan Ch'ing Wang, to whom much credit is due.

[2] Hess, Alfred F., Journ. Ind. Eng. Chem. 13 (1921) 1115.

[3] Embrey, Hartley, Philip. Journ. Sci. 22 (1923) 77.

[4] Jackson, Leila, and J. J. Moore, Journ. Inf. Dis. 19 (1916) 478.

TABLE 1.—*Showing the results of feeding certain fruits and vegetables to guinea pigs.*

English name or description of the food tested.	Local name in Peking dialect and, when possible, in Tagalog.	Scientific name.	Minimum amount of food protecting from scurvy.	Remarks.
A green leaf	Hsiang ts'ai (Chinese); onsoy or huan suy (Filipino).	*Coriandrum sativum* Linnæus.	Five grams daily	A rich source of vitamin C; 4 grams daily protected two pigs for twenty-four weeks. Other pigs on 4 grams died from scurvy.
A small red fruit common in Peking.	Hung kuo		The juice expressed from 10 grams of the fruit given daily.	A good source of vitamin C.
A tuber called by Americans "water chestnut."	Pi ch'i	*Eleocharis tuberosa* Naves	Ten cubic centimeters daily of juice expressed from the tuber.	Do.
Pomegranate	An shih liu	*Punica granatum* Linnæus	Five cubic centimeters daily of juice expressed from the fruit.	A rich source of vitamin C.
Chinese cabbage	Pai ts'ai		Three grams daily	Do.
Apparently a kind of kohlrabi.	P'ieh lan	Probably *Brassica oleracca caulorapa* or *Brassica campestris* Linnæus.	Fifteen cubic centimeters daily of juice expressed from the vegetable.	Contains a fair amount of vitamin C. One guinea pig was protected on this amount. Several guinea pigs died from scurvy.
A lettuce root	Wo sun	Variety of *Lactuca sativa* Linnæus.	Thirty cubic centimeters daily of juice expressed from this food did not afford protection.	Animals refused to take more than 30 cubic centimeters. Deficient in vitamin C.
	Hung tsao	Probably *Polygonum orientale* Linnæus.	Juice expressed from 30 grams given daily did not afford protection.	Deficient in vitamin C.
Lotus root, an esteemed Chinese vegetable.	Ou (Chinese); baino (Filipino)	*Nelumbium speciosum* Willdenow.	Ten cubic centimeters daily of juice expressed from the lotus root.	A good source of vitamin C.

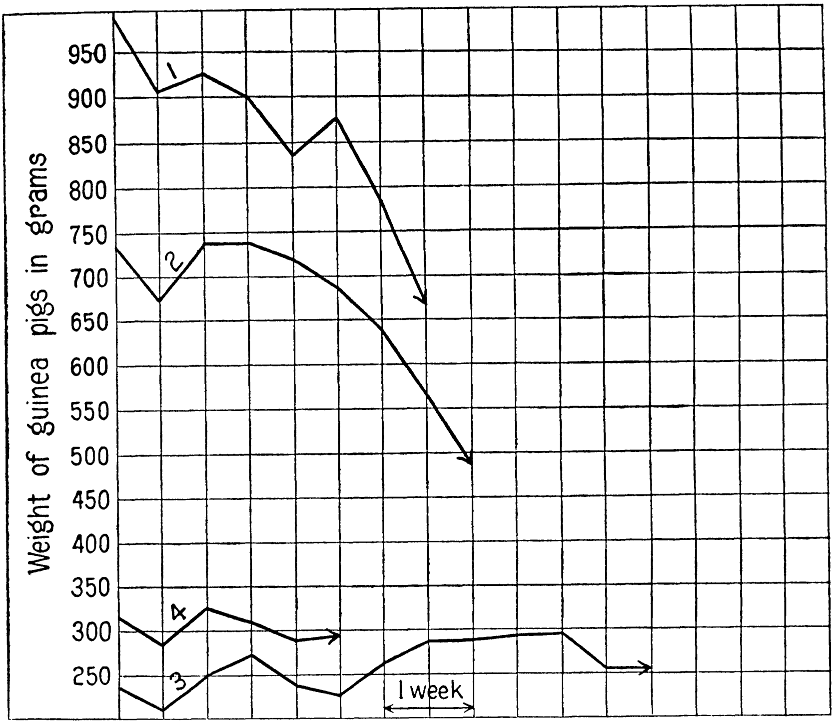

FIG. 1. Guinea pigs 1, 2, 3, and 4. These pigs received the following basal diet: Whole wheat, 86 per cent; yeast, 2 per cent; wheat bran, 3 per cent; butter, 3 per cent; calcium lactate, 3 per cent; sodium choloride, 3 per cent. In addition, 30 cubic centimeters of whole milk, previously boiled for forty-five minutes, were given daily. The animals given this basal diet were purposely chosen with entirely different initial weights, but in each case the animal died from scurvy.

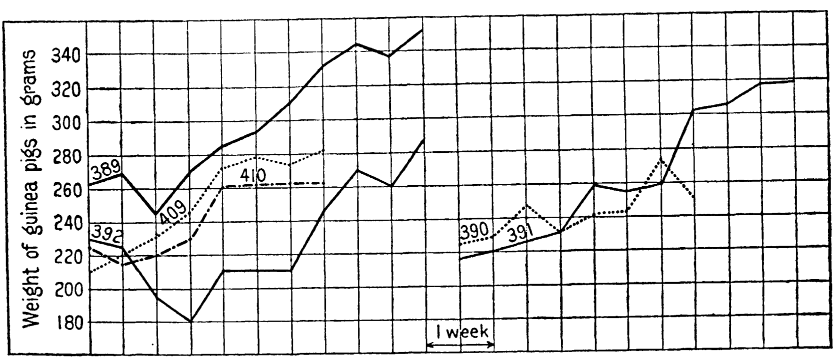

FIG. 2. Guinea pigs 389, 390, 391, 392, 409, and 410 received the basal diet and in addition 5 grams of hsiang ts'ai daily. All were protected from scurvy during the period of experimentation.

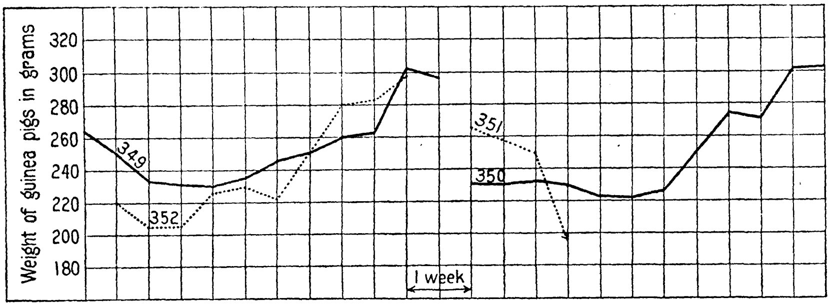

FIG. 3. Guinea pigs 349, 350, 351, and 352 received the basal diet and in addition the juice expressed from 10 grams of hung kuo daily. Pig 351 died from pneumonia. The other pigs were protected from scurvy during the period of experimentation.

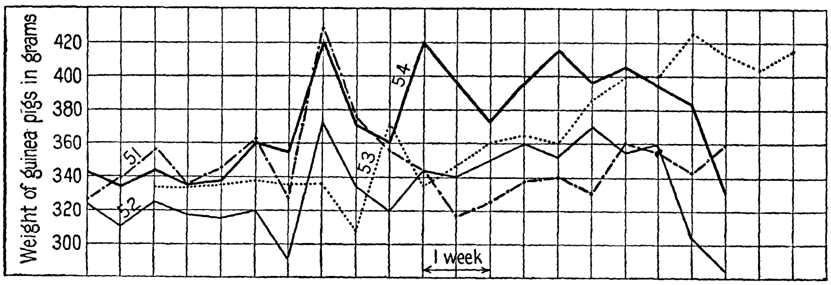

FIG. 4. Guinea pigs 51, 52, 53, and 54 received the basal diet and in addition 10 cubic centimeters of pi ch'i juice daily. All of the animals were protected from scurvy with the exception of pig 52 which died from scurvy after nine weeks of this diet.

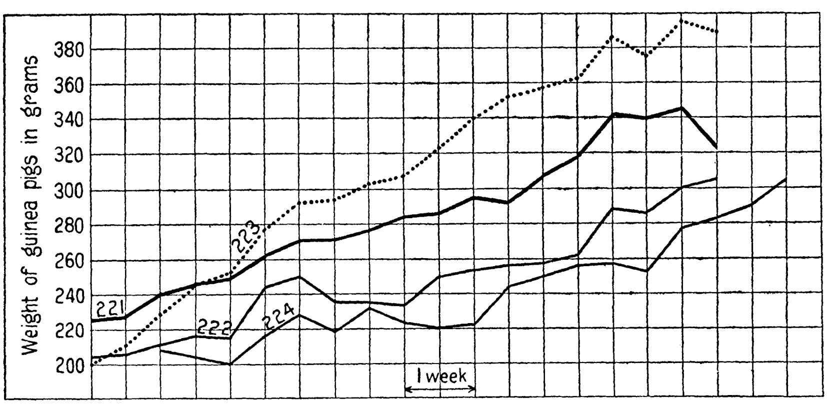

FIG. 5. Guinea pigs 221, 222, 223, and 224 received the basal diet and in addition 5 cubic centimeters of pomegranate juice daily. All of the animals on this diet were protected from scurvy for a period of nine weeks.

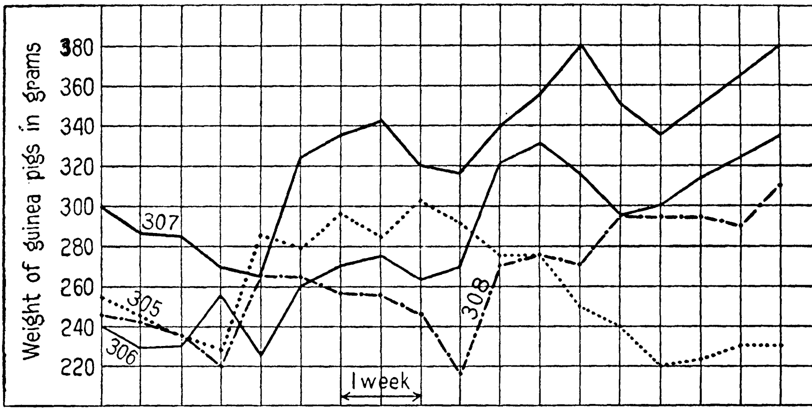

FIG. 6. Guinea pigs 305, 306, 307, and 308 received the basal diet and in addition 3 grams of pai ts'ai, or Chinese cabbage, daily. All of the pigs were protected from scurvy for a period of more than eight weeks.

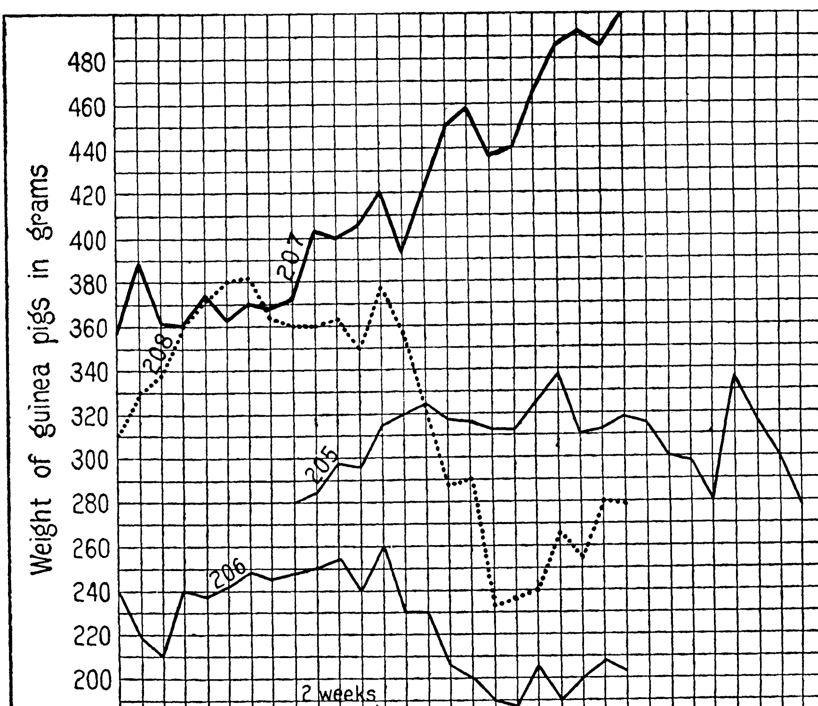

FIG. 7. Guinea pigs 205, 206, 207, and 208 received the basal diet and in addition 15 cubic centimeters of the juice of p'ieh lan daily. All except pig 206 were protected from scurvy for a period of twelve weeks, but only one attained normal weight.

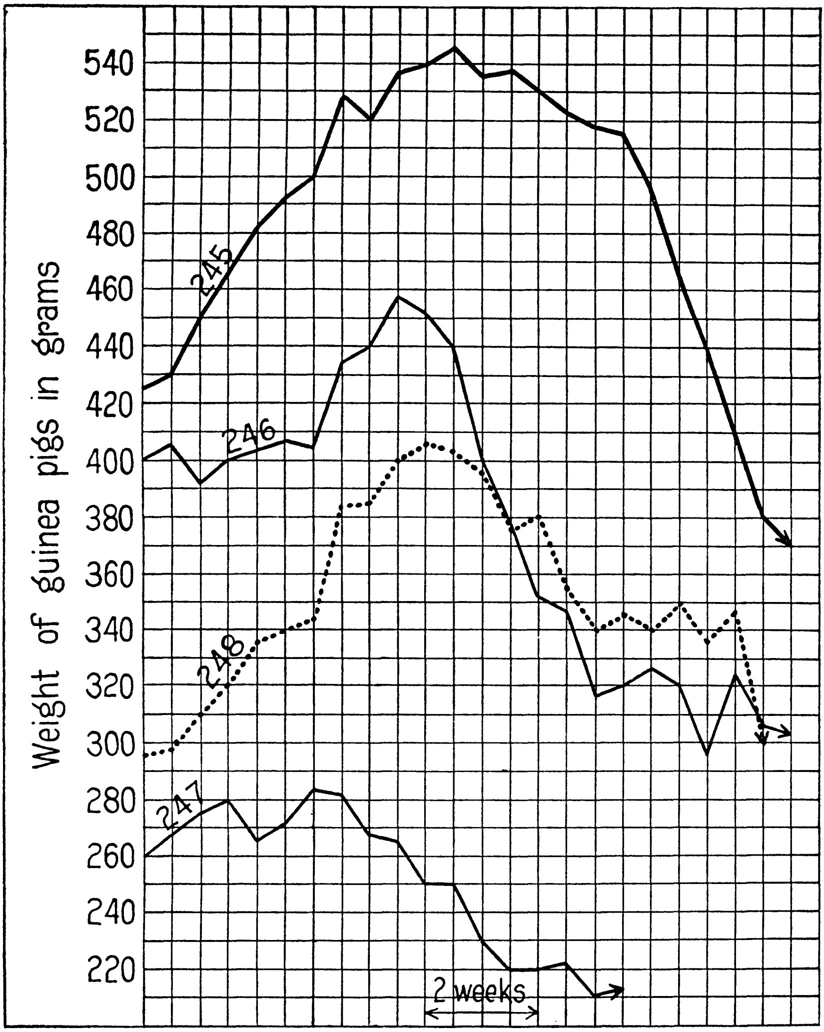

FIG. 8. Guinea pigs 245, 246, 247, and 248 received the basal diet and 30 cubic centimeters of juice expressed from wo sun daily. This amount of wo sun did not protect from scurvy and all of the pigs died. They could not be induced to take more than 30 cubic centimeters of wo sun. We succeeded in making them take the 30 cubic centimeters mentioned by feeding small amounts only, at spaced intervals during the day. The pigs lived from eight to ten weeks.

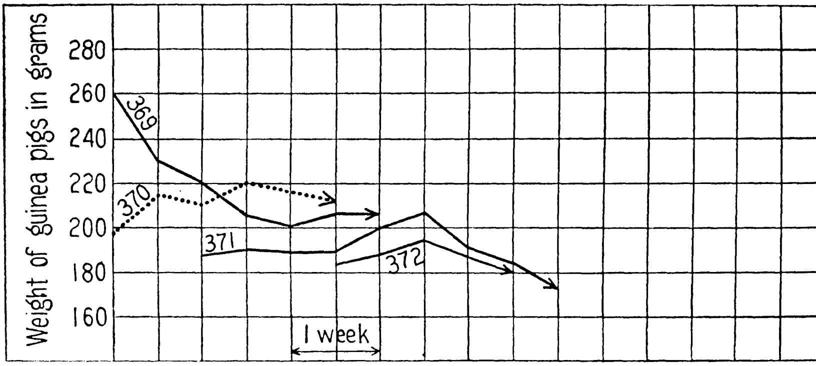

FIG. 9. Guinea pigs 369, 370, 371, and 372 received the basal diet and in addition the juice expressed from 30 grams of hung tsao daily. All of the pigs died from scurvy in from three to four weeks.

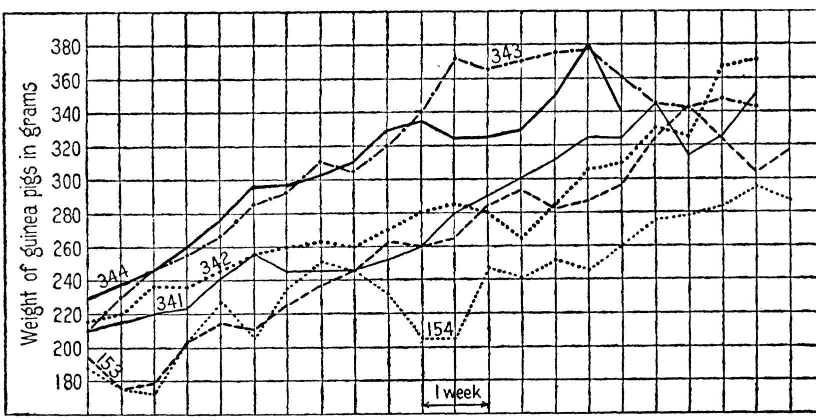

FIG. 10. Guinea pigs 341, 342, 343, 344, 153, and 154 received the basal diet and in addition 10 cubic centimeters of lotus root (ou) juice daily. All were protected from scurvy for a period of ten weeks. Pig 344 died from pneumonia, but post-mortem examination showed also a slight tendency toward scurvy.

ILLUSTRATIONS

TEXT FIGURES

[The numbers above the growth curves are the identification numbers of the animals; the weights of the guinea pigs are shown by the figures on the axes of ordinates; the number of weeks of experimentation is indicated by the numbers on the axes of abscissæ. An arrowhead terminating the growth curve indicates the death of the animal in question. Omission of the arrowhead indicates that the animal was still living at the end of the experiment.]

FIG. 1. Guinea pigs 1, 2, 3, and 4. These pigs received the following basal diet: Whole wheat, 86 per cent; yeast, 2 per cent; wheat bran, 3 per cent; butter, 3 per cent; calcium lactate, 3 per cent; sodium chloride, 3 per cent. In addition, 30 cubic centimeters of whole milk, previously boiled for forty-five minutes, were given daily. The animals given this basal diet were purposely chosen with entirely different initial weights, but in each case the animal died from scurvy.

2. Guinea pigs 389, 390, 391, 392, 409, and 410 received the basal diet and in addition 5 grams of hsiang ts'ai daily. All were protected from scurvy during the period of experimentation.

3. Guinea pigs 349, 350, 351, and 352 received the basal diet and in addition the juice expressed from 10 grams of hung kuo daily. Pig 351 died from pneumonia. The other pigs were protected from scurvy during the period of experimentation.

4. Guinea pigs 51, 52, 53, and 54 received the basal diet and in addition 10 cubic centimeters of pi ch'i juice daily. All of the animals were protected from scurvy with the exception of pig 52 which died from scurvy after nine weeks of this diet.

5. Guinea pigs 221, 222, 223, and 224 received the basal diet and in addition 5 cubic centimeters of pomegranate juice daily. All of the animals on this diet were protected from scurvy for a period of nine weeks.

6. Guinea pigs 305, 306, 307, and 308 received the basal diet and in addition 3 grams of pai ts'ai, or Chinese cabbage, daily. All of the pigs were protected from scurvy for a period of more than eight weeks.

7. Guinea pigs 205, 206, 207, and 208 received the basal diet and in addition 15 cubic centimeters of the juice of p'ieh lan daily. All except pig 206 were protected from scurvy for a period of twelve weeks, but only one attained normal weight.

8. Guinea pigs 245, 246, 247, and 248 received the basal diet and 30 cubic centimeters of juice expressed from wo sun daily. This amount of wo sun did not protect from scurvy, and all of the pigs died. They could not be induced to take more than 30 cubic centimeters of wo sun. We succeeded in making them

take the 30 cubic centimeters mentioned by feeding small amounts only, at spaced intervals during the day. The pigs lived from eight to ten weeks.

FIG. 9. Guinea pigs 369, 370, 371, and 372 received the basal diet and in addition the juice expressed from 30 grams of hung tsao daily. All of the pigs died from scurvy in from three to four weeks.

10. Guinea pigs 341, 342, 343, 344, 153, and 154 received the basal diet and in addition 10 cubic centimeters of lotus root (ou) juice daily. All were protected from scurvy for a period of ten weeks. Pig 344 died from pneumonia, but post-mortem examination showed also a slight tendency toward scurvy.

CERTAIN PROTEINS ADDED TO MUNG BEAN, OR TO WHITE OR RED SORGHUM VULGARE, INCREASE THE FERTILITY OF MICE

By Hartley Embrey Sherman

Of the Laboratories of Food Chemistry, Peking Union Medical College Peking, China, and the Bureau of Science, Manila[1]

TWENTY-SIX TEXT FIGURES

In an article published in 1921,(1) the author proved that the proteins of mung bean were biologically complete, since all the first generation of Chinese white mice grew to normal weight when the mung bean, *Phaseolus aureus* Roxburgh, was used as the sole source of protein. In the same article attention was drawn to the fact that the diet of chart 3 (mung bean, 89.3 per cent; salt mixture, 3.7 per cent; dextrin, 2 per cent; and butter, 5 per cent) gave decidedly subnormal reproduction, and none of the second generation lived through the period of lactation. Charts 6 and 7 of the same article showed that the substitution of 5 and 8 per cent, respectively, of casein for the same amount of mung bean increased the fertility and also the number of young that could be successfully raised on that diet.

Chart 21 of the same article showed that a diet consisting of red kaoliang (a red variety of kaoliang, scientifically known as *Sorghum vulgare*), 91.3 per cent; a mixture of salts, 3.7 per cent; and butter, 5 per cent, gave subnormal growth in the first generation. The reproduction rate was very low, and none of the second generation survived.

Chart 22 of the same article showed that the substitution of 9 per cent of casein in the diet of chart 21 for the same amount of red kaoling improved the growth of mice of the first generation, and increased their fertility and their rate of reproduction, but none of the second generation lived beyond the period of lactation.

[1] Thanks are due to Mr. Tsan Ch'ing Wang, my assistant in the Peking Union Medical College, for technical help and coöperation in all of the laboratory work done in China.

Chart 27 of the same article showed that a diet of white unpolished kaoliang (the white variety of *Sorghum vulgare*), 91.3 per cent; a mixture of salts, 3.7 per cent; and butter, 5 per cent, gave almost normal growth in the first generation, but reproduction was subnormal and none of the second generation lived.

Chart 28 of the same article showed that lowering the amount of white kaoliang to 45 per cent and adding 9 per cent of casein to the diet in chart 27 gave normal growth in the first generation. The rate of reproduction was improved, and five individuals of the second generation grew to normal weight on this diet.

To sum up the results previously reported, both mung bean and white kaoliang gave good growth in the first generation and red kaoliang gave fair growth in the first generation; but each of these food substances, when used alone as the sole source of protein, failed to give normal birth rates and also failed to nourish the mother mice adequately, so that the few mice that were born on this diet did not live through the period of lactation.

It was not surprising, therefore, that Maxwell, reasoning by analogy from the sterility results showed by my mice on the above and other similar diets, found that many cases of apparent pregnancy toxæmia in humans were due merely to food deficiency.(2)

In view of the fact that mung bean and white and red kaoliang are among the main cheap food substances found in North China, and, consequently, are used as the sole sources of protein in the diets of thousands of the poorer Chinese, it seemed important to us to find out what other cheap foods, also native to North China, could be added to mung bean and to red and to white kaoliang, in order to increase the fertility of the first generation, to enable the young to live through the period of lactation, and to attain normal growth in the second generation.

The experiments reported in this paper were conducted before July, 1923, but remained unpublished until the present time. They should be of interest as preceding the subsequent work done by various workers on vitamin E, and the results reported here should also have a special practical value in formulating cheap diets of native foods suitable for hospitals, schools, and other public institutions in the Orient.

The proteins selected to be tested for their effects as supplements to mung bean and to white and to red kaoliang were

peanuts, after the fat had been extracted with ether; soy bean, after the fat had been extracted with ether; gelatine; egg white; and casein. These proteins were all chosen on account of their cheapness and, with the exception of casein, on account also of their being found in abundance almost everywhere in the Orient. The peanut press cake and the soy-bean press cake are especially cheap; but, unfortunately, since they have been used very little in the past for human food, they often are found in the market in a filthy condition, fermenting, and strong with the odor and taste of rancid oils. Therefore, I used in these experiments only the clean foods prepared in the laboratory after the oils had been removed by extraction with ether. The substances remaining after extraction resembled the commercial press cake from a chemical point of view only, but they did not have any of the deleterious effects which might have resulted from the use of dirty, rancid, fermenting press cake. In feeding on a large scale, if clean press cake cannot be bought, the cheapness of the original peanut and soy bean will warrant their being used as supplementary foods.

EXPERIMENTAL METHODS

As far as possible we used the technic of Osborne and Mendel. Our standard salt mixture consisted of sodium chloride, 0.173 gram; magnesium sulphate, 0.266 gram; sodium dihydrogen phosphate, 0.347 gram; potassium monohydrogen phosphate, 0.954 gram; soluble calcium phosphate, 0.540 gram; ferric citrate, 0.118 gram; and calcium lactate, 1.300 grams.

Butter was melted below 45° C. and the clear liquid decanted and centrifuged for an hour.

The Chinese foods investigated were cooked for forty minutes in an autoclave at 15 pounds pressure, and dried in a current of air below 60° C. The ingredients used in our diets were ground so fine that the animals were unable to separate them. The food mixtures had the percentage composition shown in the graphs, and were given ad libitum.

In all of the feeding work reported in this paper, Chinese white mice were used as experimental animals. Their growth curves were compared to the standard growth curves reported in chart 1 in a previously published article.(1) White mice were used because we were unable to secure white albino rats at the time that the experimental work described in this article was being done.

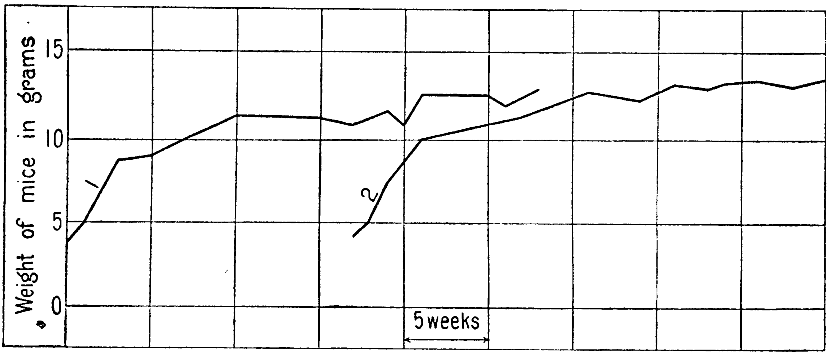

FIG. 1. These curves represent, 1, the average of ten growth curves made from female mice and, 2, the average of ten growth curves made from male mice. The diet was given in three separate containers ad libitum. The first had a homogeneous mixture of yellow soy bean, 45 per cent; casein, 3 per cent; butter, 5 per cent; salt mixture, 3 per cent; and dextrin, 44 per cent. The second container had fresh cabbage or spinach. The third had either fresh milk or mashed hard-boiled egg. During this experiment forty young were born to the ten pairs of mice. More than thirty of the mice of the second generation lived and attained normal weight. The curves in fig. 1, of the animals receiving this liberal diet, were taken as our standard growth curves.

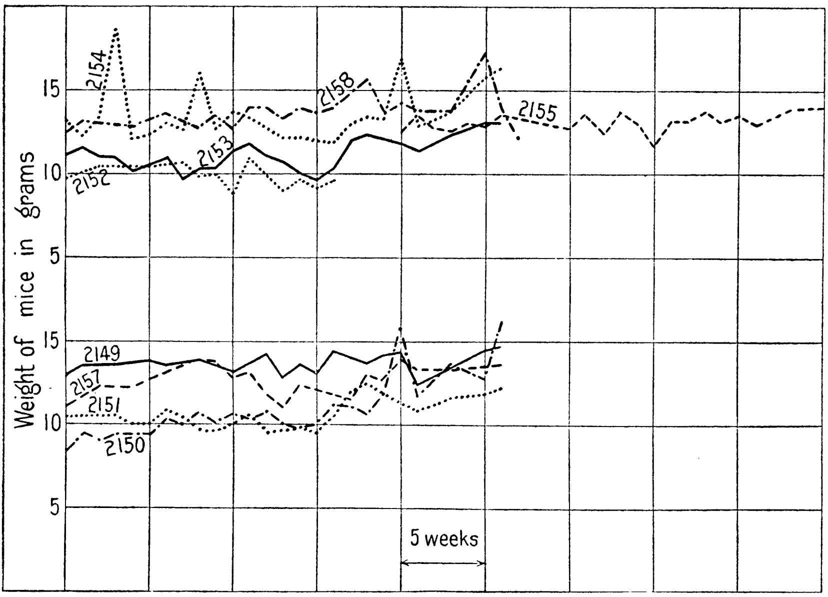

FIG. 2. These curves show the growth of the first generation of mice receiving the following diet: Mung bean, 84.3 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent; peanut, previously extracted with ether, 5 per cent. Growth was normal.

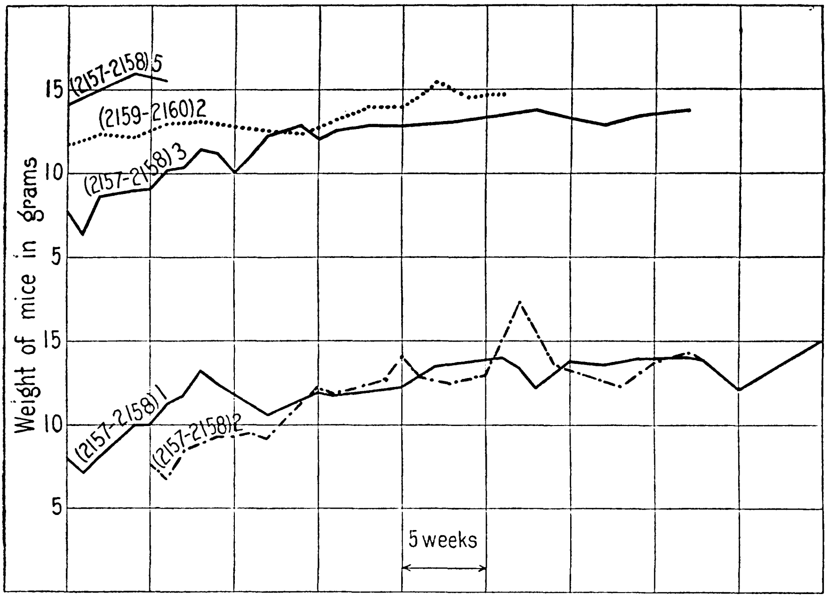

FIG. 3. These curves represent the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 2. Five typical curves only are shown, although ten young lived and grew to normal weight.

SUMMARY OF EXPERIMENTAL WORK

1. When mung bean (*Phaseolus aureus* Roxburgh) was used as the sole source of protein in the diet of Chinese white mice, the first generation showed normal growth, thus proving that the proteins must be biologically complete. Reproduction, however, was subnormal, and none of the second generation survived the period of lactation. The addition of small quantities of casein improved the birth rate. (1)

Five per cent of fat-free peanut, added to the mung-bean diet by substituting it for the equivalent amount of the mung bean, raised the rate of reproduction to about three-fourths normal. The second and the third generation on this diet showed good growth.

2. Five per cent of gelatine, added to the mung-bean diet by replacing the equivalent amount of mung bean, raised the rate of reproduction to about three-fourths normal. All of the second generation grew to normal weight.

3. Five per cent of egg white, added to the mung-bean diet by replacing the equivalent amount of mung bean, improved the rate of reproduction to about one-fourth normal. The second generation on this diet grew to almost normal weight.

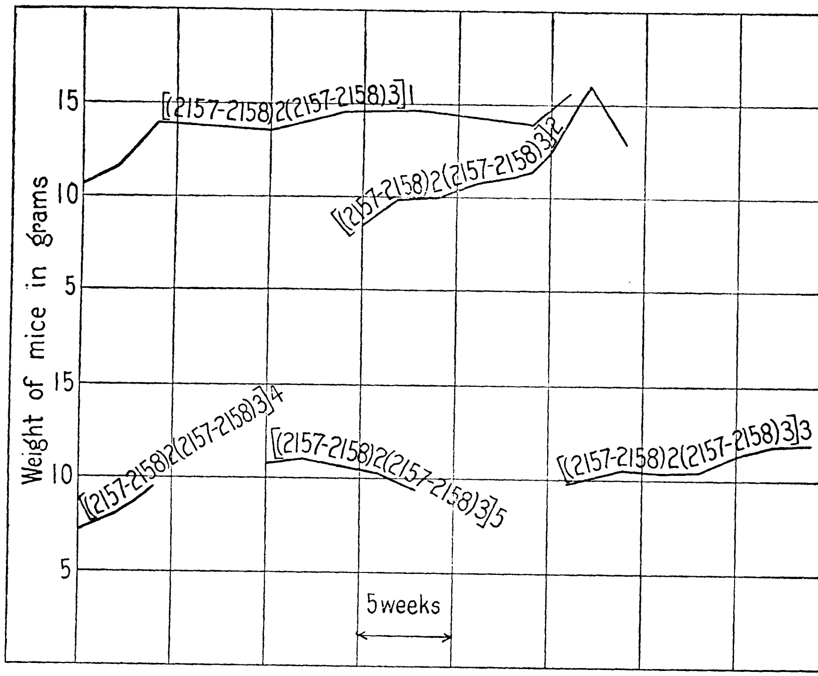

FIG. 4. These curves show the growth of the third generation on the diet that was fed to the animals whose growth is recorded in fig. 2. Inspection of figs. 2, 3, and 4 shows that the rate of reproduction was greatly improved by the addition of 5 per cent of peanut. Ten of the second generation lived and grew to normal weight. The growth of the second and the third generation on this diet was normal.

4. Five per cent of fat-free soy bean, added to the mung-bean diet by replacing an equivalent amount of mung bean, improved the rate of reproduction slightly. Two of the second generation lived, and one of them attained normal weight.

5. When white kaoliang (a Chinese variety of white edible sorghum, scientifically known as *Sorghum vulgare*) was used as the sole source of protein in the diet of Chinese white mice, the first generation showed good growth. Reproduction was subnormal, however, and few of the second generation survived the period of lactation. Fifteen per cent of mung bean, added to the white kaoliang diet by replacing an equivalent amount of white kaoliang, raised the birth rate to normal. All of the second and third generations on this diet showed good growth.

6. Five per cent of fat-free soy bean, added to the white kaoliang diet by replacing an equivalent amount of white kaoliang, raised the birth rate to normal. During the time of the experiment all of the second generation showed good growth.

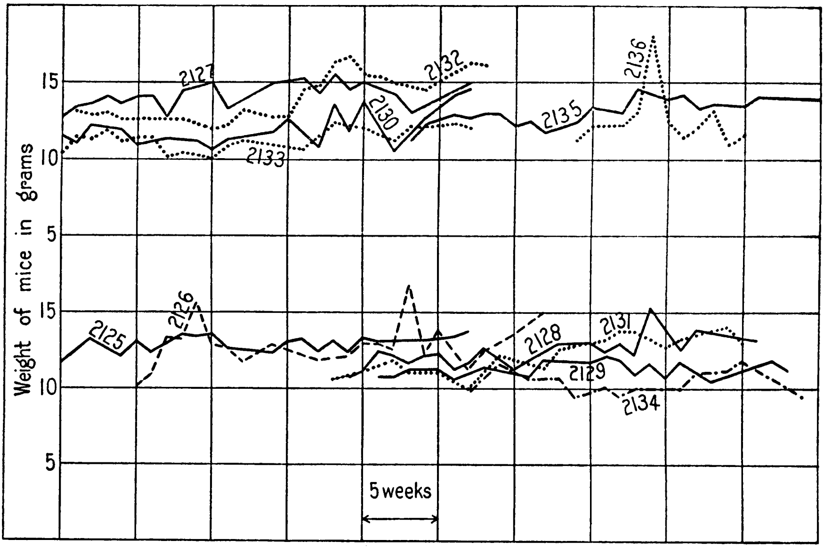

FIG. 5. These curves show the growth of the first generation of mice receiving the following diet: Mung bean, 84.3 per cent; gelatine, 5 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent. Growth was normal.

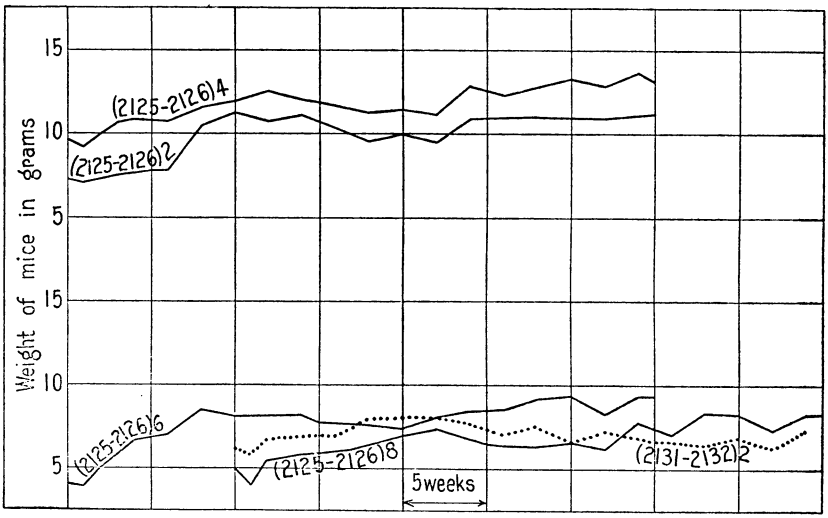

FIG. 6. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 5. The addition of 5 per cent of gelatine improved the fertility of the parent mice. The rate of growth of the second generation was normal except in the case of one mouse whose rate of growth was slightly subnormal.

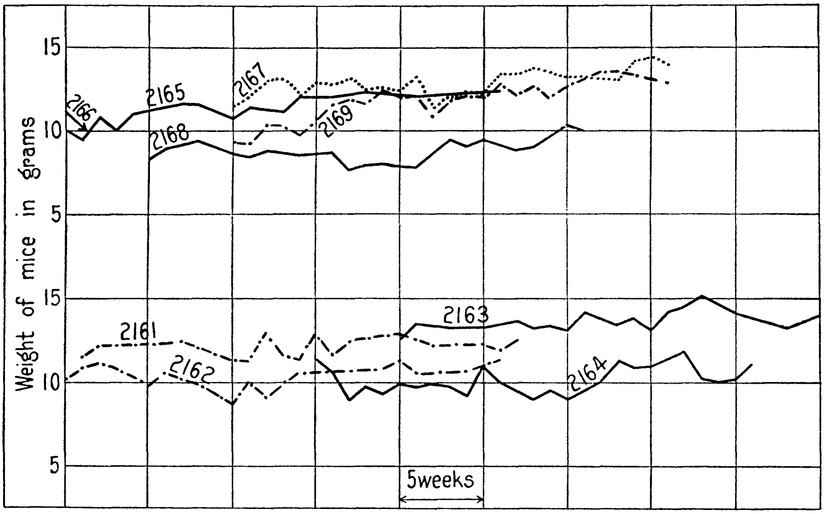

FIG. 7. These curves show the growth of the first generation of white mice on the following diet: Mung bean, 84.3 per cent; soy bean, with the fat removed by previous extraction with ether, 5 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent.

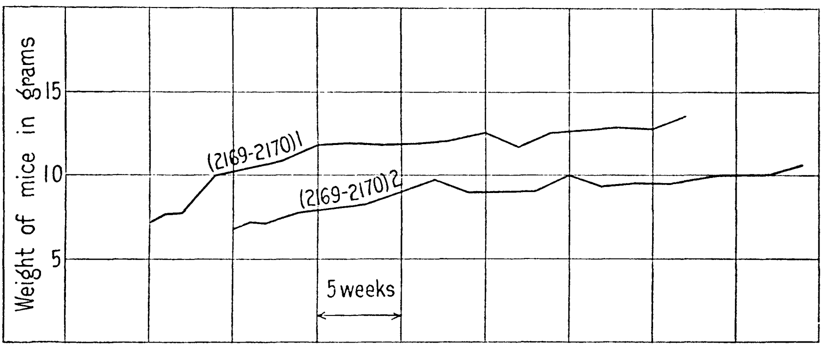

FIG. 8. These curves are for the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 7. The rate of reproduction was slightly improved by the addition of 5 per cent of fat-free soy bean. Two of the second generation lived, and one of them reached normal weight.

7. The addition of 5 per cent of fat-free peanut to the white kaoliang diet increased the birth rate to normal. All of the second generation showed good growth on this diet.

8. The addition of 5 per cent of casein to the white kaoliang diet raised the birth rate to almost normal. The second generation on this diet showed good growth.

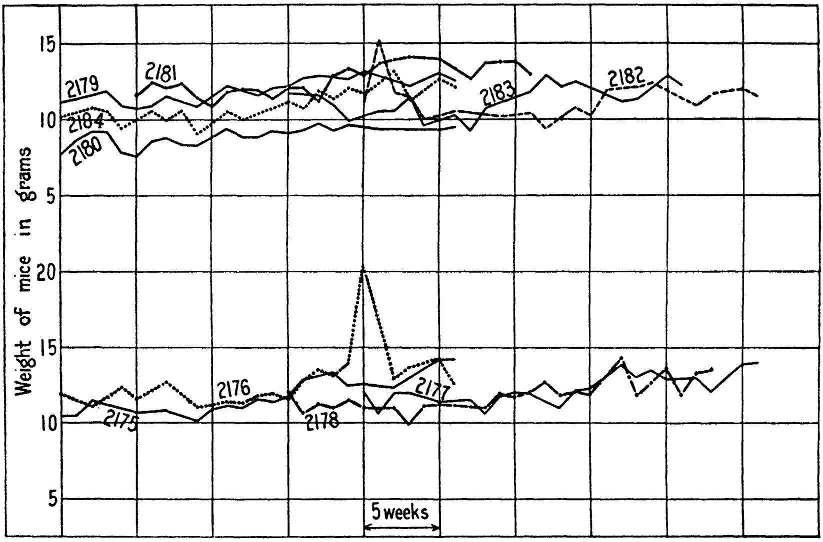

FIG. 9. These curves show the growth of the first generation of mice on the following diet: Mung bean, 92 per cent; sodium chloride and calcium carbonate, 3 per cent; egg white, 5 per cent. All of the first generation showed normal growth except one mouse, whose growth was slightly subnormal.

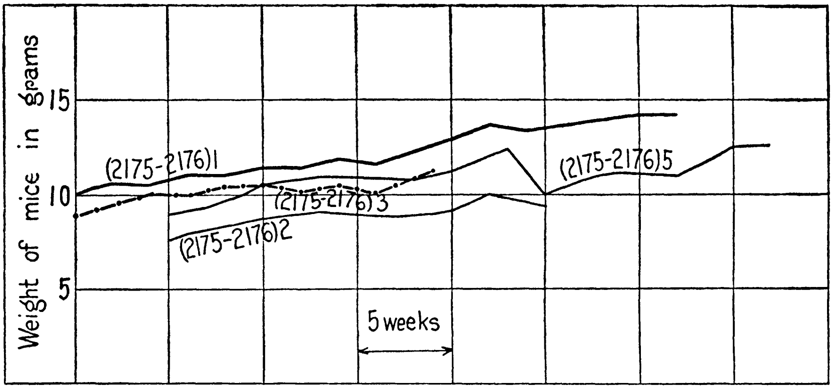

FIG. 10. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 9. The addition of 5 per cent of egg white improved the rate of reproduction.. Four of the young lived, and two of them attained normal growth.

9. A diet of 50 per cent of ordinary millet and 50 per cent of white kaoliang increased the birth rate slightly. Three of the second generation survived and showed good growth.

10. When red kaoliang (the red variety of *Sorghum vulgare*) was used as the sole source of protein in the diet of white

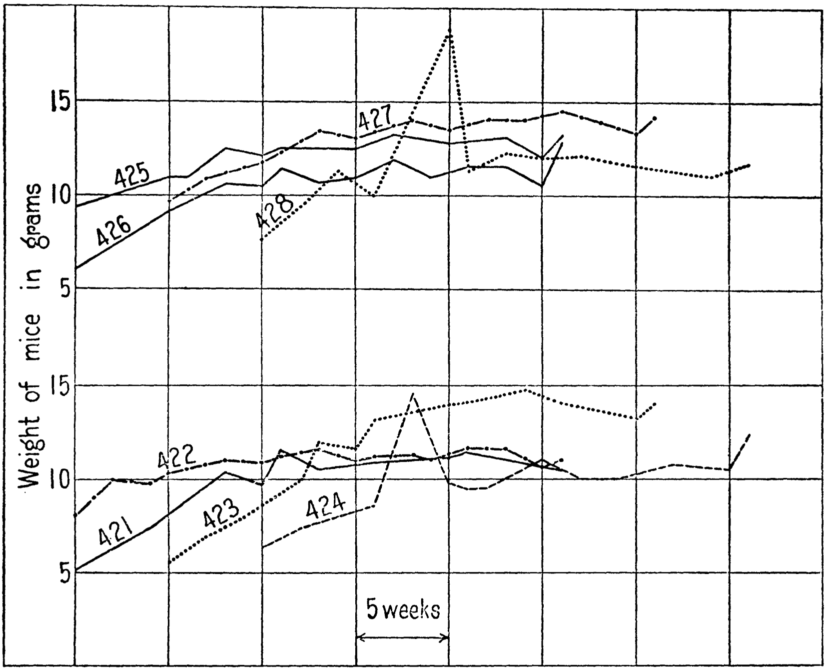

FIG. 11. These curves show the growth of the first generation on the following diet: Red kaoliang, 86 per cent; casein, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. The addition of 5 per cent of casein improved the growth of the first generation on a red kaoliang diet.

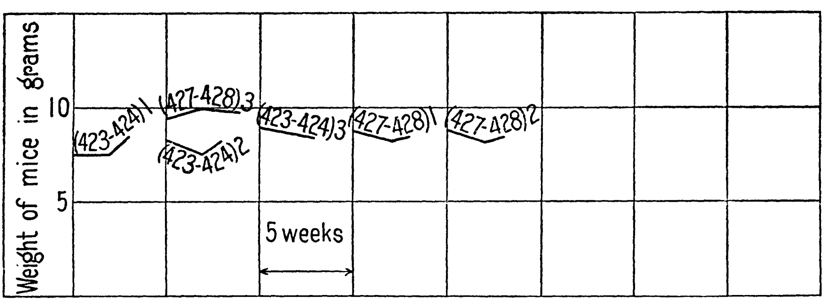

FIG. 12. These curves represent the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 11. While the addition of 5 per cent of casein improved the rate of reproduction, the six young of the second generation that lived seemed not to be gaining normally and the experiment wsa stopped.

Chinese mice, the mice did not attain normal growth in the first generation. Reproduction was subnormal, and none of the second generation survived.(1) When 5 per cent of casein was added to the diet, by substituting it for an equal amount of red kaoliang, the rate of reproduction was improved to almost one-

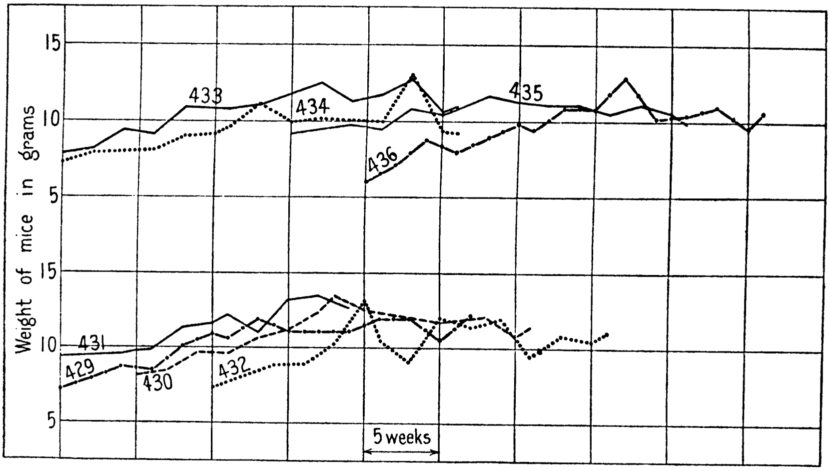

FIG. 13. These growth curves are for the first generation of mice on the following diet: Red kaoliang, 86 per cent; peanut, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. The rate of reproduction was low, and none of the second generation survived.

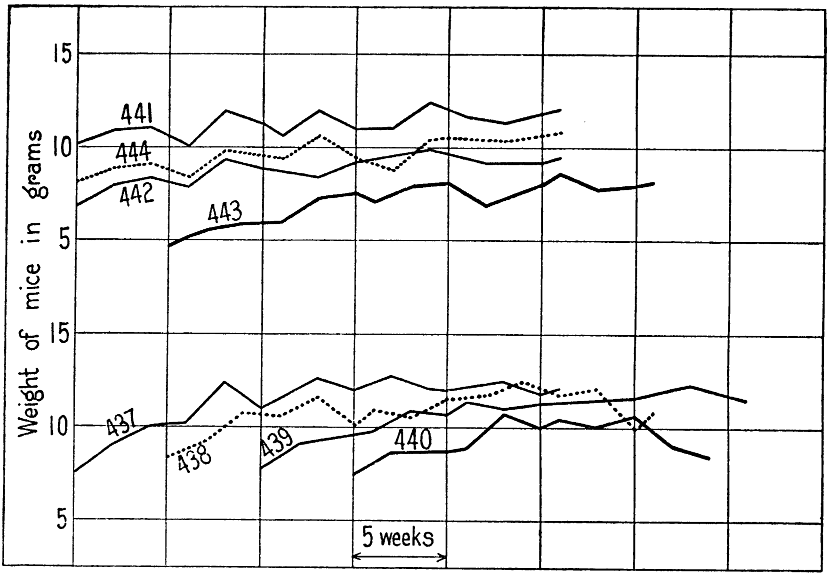

FIG. 14. These curves show the growth of the first generation of mice on the following diet: Red kaoliang, 86 per cent; soy bean, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. This diet produced only one litter of two mice, neither of which lived.

half normal. Six of the second generation lived through the period of lactation. The experiment was terminated at that time.

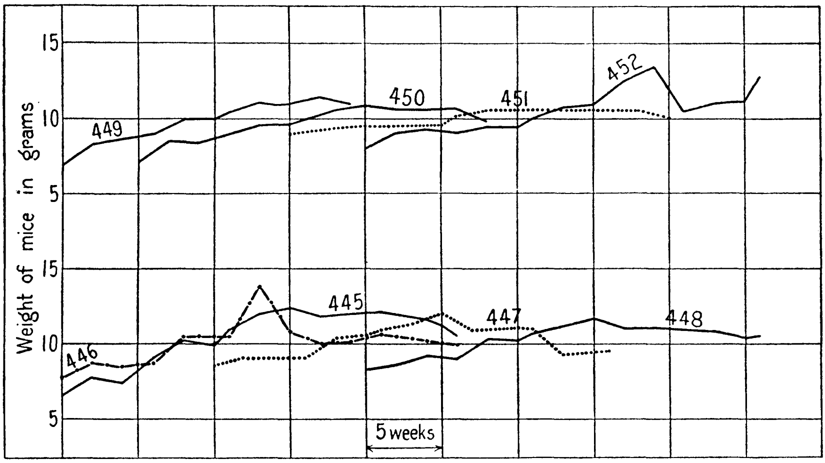

FIG. 15. These curves give the growth of the first generation of mice on the following diet: Red kaoliang, 76 per cent; mung bean, 15 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. Two litters of young were born, but only one mouse lived. Since the growth of this mouse was subnormal the experiment was discontinued.

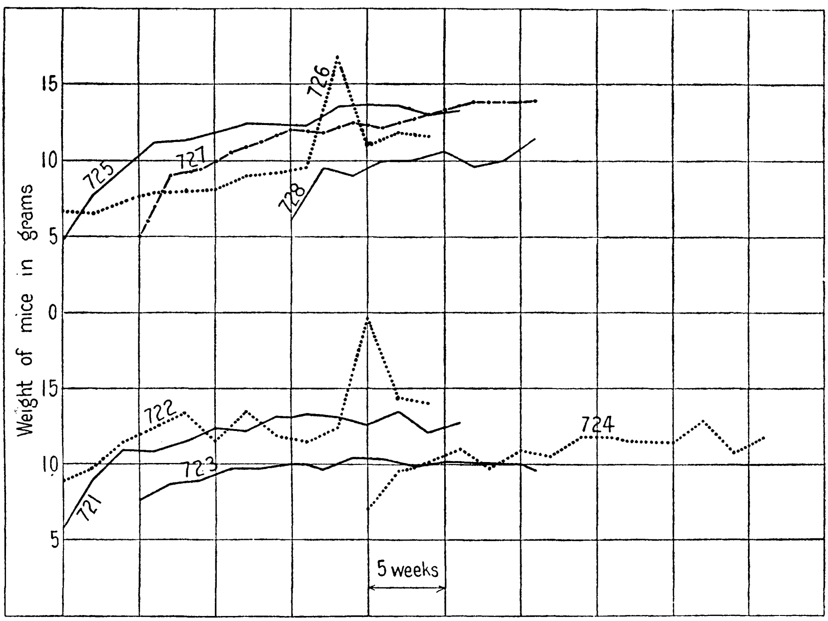

FIG. 16. These curves show the growth of the first generation of white mice on the following diet: White kaoliang, 86 per cent; casein, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. Growth was normal and the reproduction was improved by the addition of 5 per cent of casein.

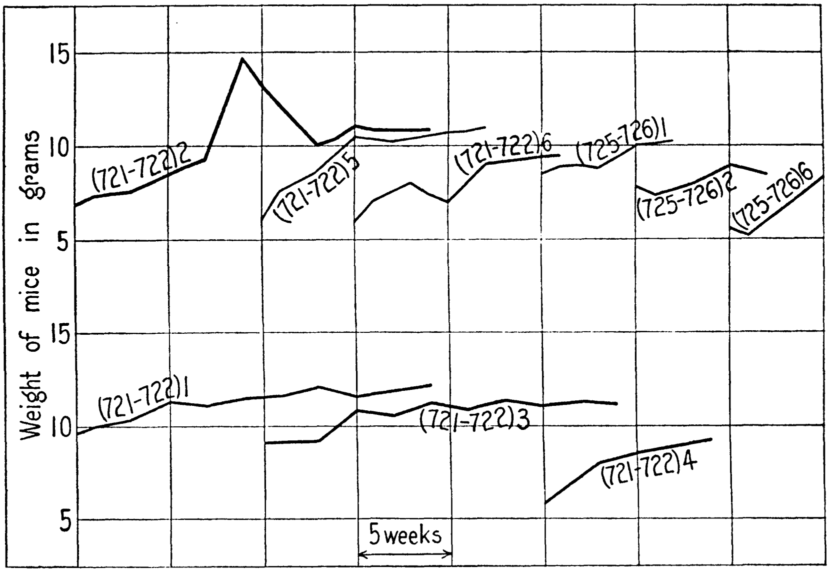

FIG. 17. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 16.

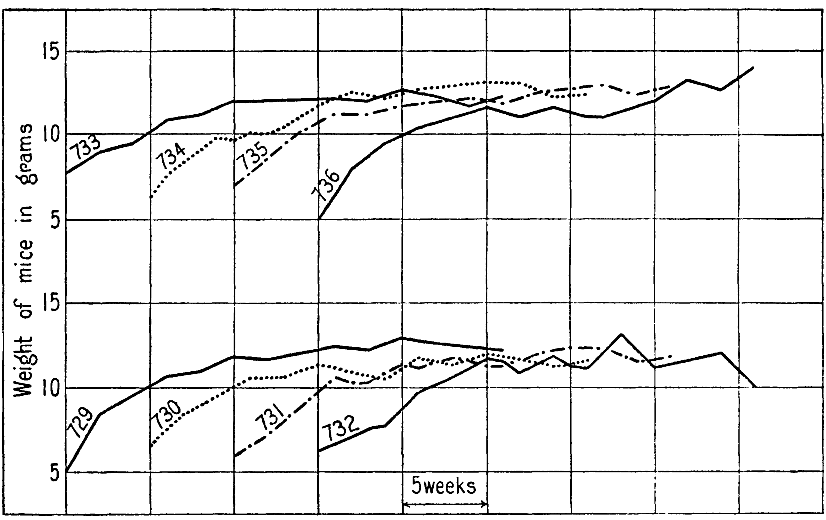

FIG. 18. These curves give the growth of the first generation of mice on the following diet: White kaoliang, 86 per cent; peanut, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. The growth of the first generation was excellent, and reproduction was normal.

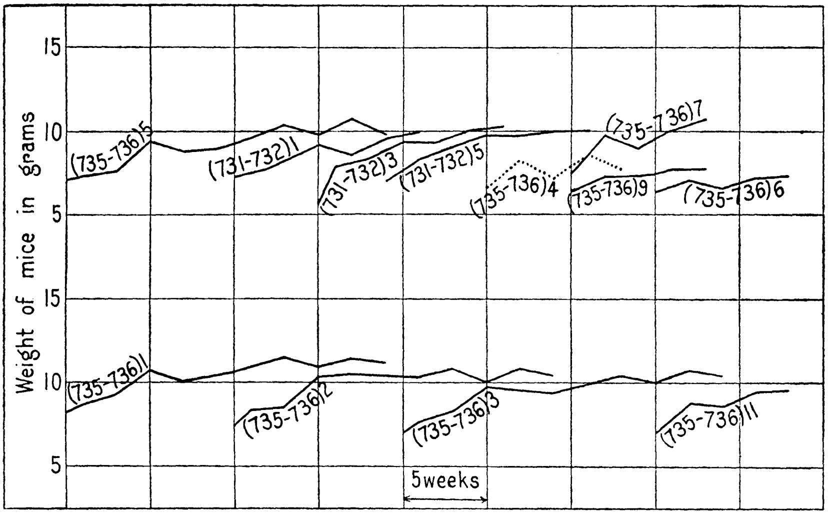

FIG. 19. These curves show the growth of the second generation on the diet that was fed to the animals whose growth is recorded of the young lived through the period of lactation and were showing good growth at the termination of the experiment.

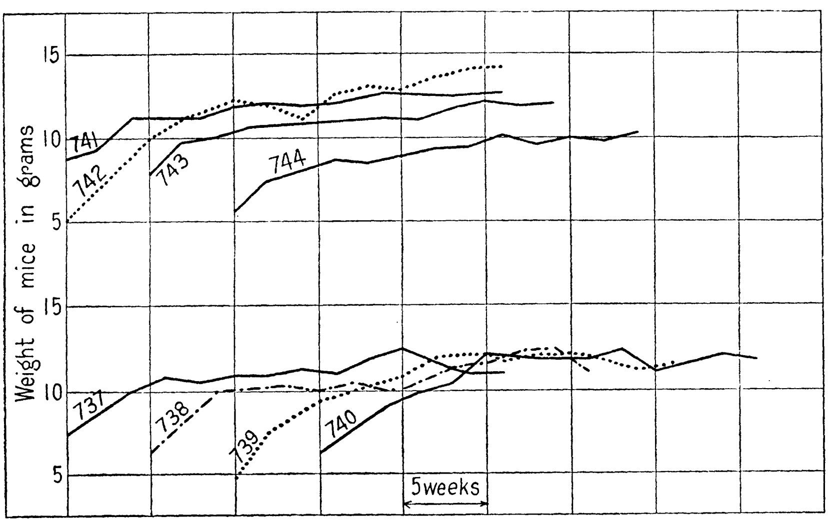

FIG. 20. These curves give the growth of the first generation of mice on a diet of white kaoliang, 86 per cent; soy bean, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. Growth was excellent except in the case of one mouse. Reproduction was normal.

11. Fifteen per cent of mung bean, added to the diet of red kaoliang by reducing the red kaoliang an equal amount, raised the rate of reproduction slightly. One of the second generation survived the period of lactation.

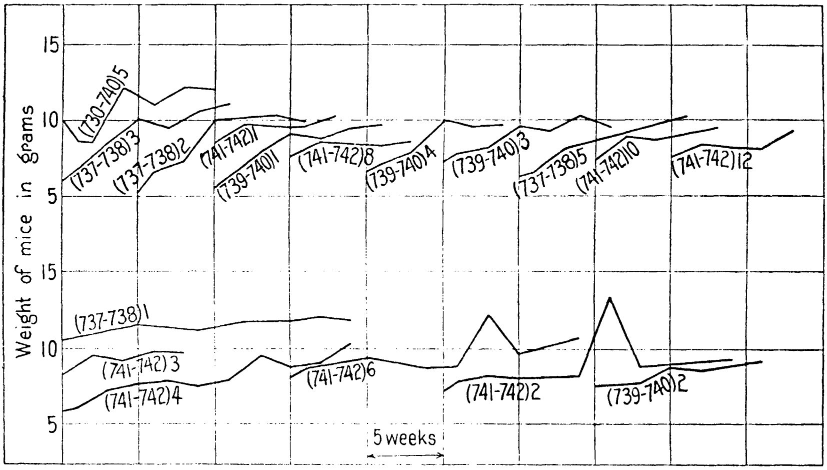

FIG. 21. These curves represent the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 20. All of the young lived through the period of lactation and were showing good subsequent growth at the termination of the experiment. Before the termination of the experiment two litters of the third generation were born. The young of the third generation were showing good growth at the conclusion of the experiment.

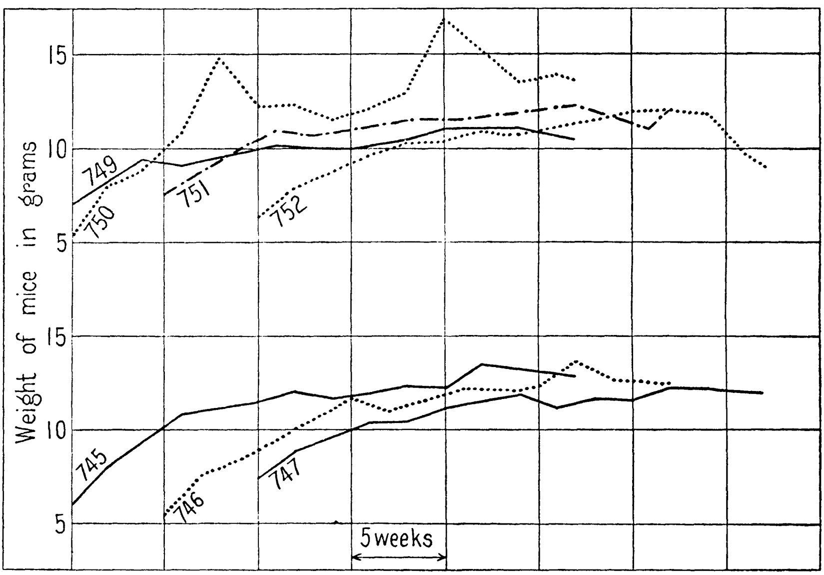

FIG. 22. These curves give the growth of the first generation of mice on a diet of white kaoliang, 76 per cent; mung bean, 15 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. The growth and the rate of reproduction were normal.

12. Five per cent of fat-free peanut and 5 per cent of fat-free soy bean, added separately to the red kaoliang diet, did not in-

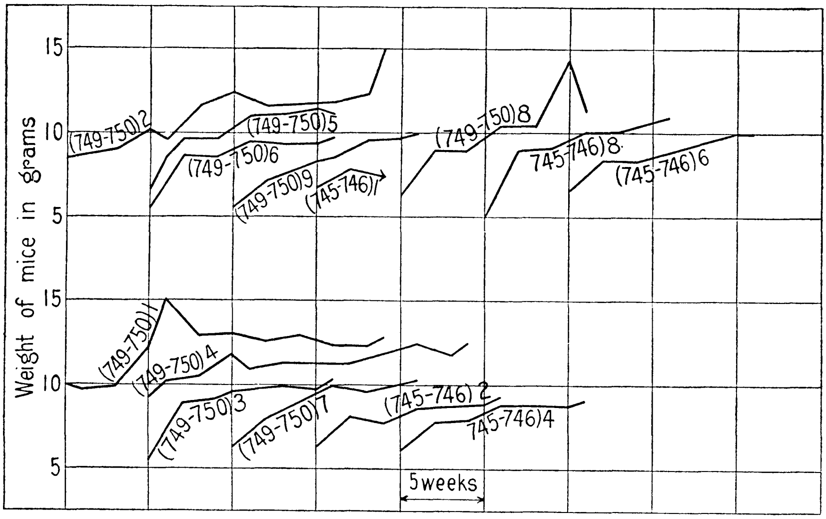

FIG. 23. These curves give the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 22.

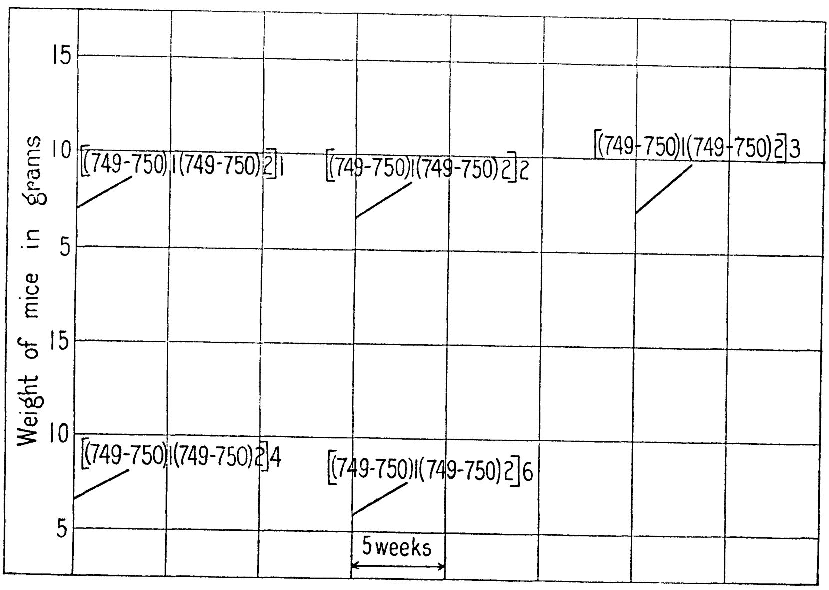

FIG. 24. These curves give the growth of the third generation on the diet that was fed to the animals whose growth is recorded in fig. 22. Growth was good in both cases.

crease the birth rate appreciably, and none of the young mice survived the period of lactation in either case.

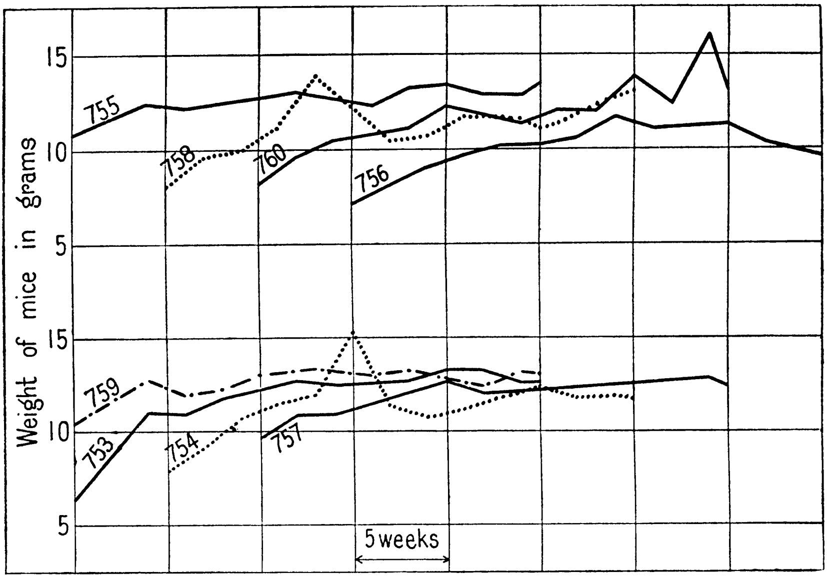

FIG. 25. These curves show the growth of the first generation of Chinese white mice on a diet which consisted of only white kaoliang, 50 per cent, and millet, 50 per cent. Growth was good; the addition of the millet improved the birth rate somewhat, but it was still below normal.

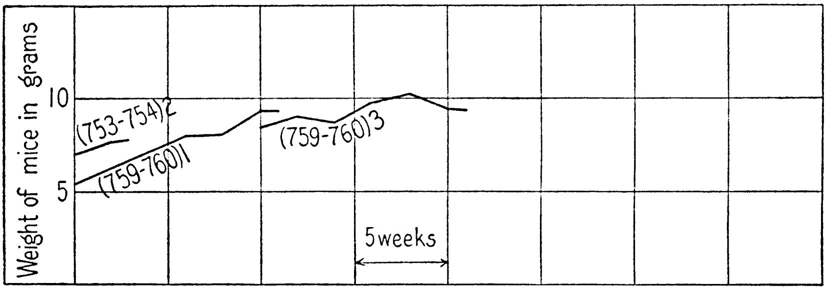

FIG. 26. These curves show the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 25. Three of the second generation lived through the period of lactation and were showing good growth at the termination of the experiment.

CONCLUSIONS

1. To increase the fertility of white mice and to assure good growth of the second generation, from among the foods tested, the best supplements for a mung-bean (*Phaseolus aureus* Roxburgh) diet are small quantities of fat-free peanut, of gelatine, or of casein. The best supplements for the white variety of edible sorghum (*Sorghum vulgare*) are small quantities of mung bean, of fat-free soy bean, or of fat-free peanut.

2. Not one of the foods tested as supplements to the red variety of *Sorghum vulgare* was able to raise the rate of reproduction of the first generation, nor the number of young of the second generation surviving the period of lactation, to normal. Casein, however, was a better supplementary food in a diet of red *Sorghum vulgare* than was mung bean, fat-free peanut, or fat-free soy bean.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. These curves represent, 1, the average of ten growth curves made from female mice and, 2, the average of ten growth curves made from male mice. The diet was given in three separate containers ad libitum. The first container had a homogeneous mixture of yellow soy bean, 45 per cent; casein, 3 per cent; butter, 5 per cent; salt mixture, 3 per cent; and dextrin, 44 per cent. The second container had fresh cabbage or spinach. The third had either fresh milk or mashed hard-boiled egg. During this experiment forty young were born to the ten pairs of mice. More than thirty of the mice of the second generation lived and attained normal weight. The curves in fig. 1, of the animals receiving this liberal diet, were taken as our standard growth curves.

2. These curves show the growth of the first generation of mice receiving the following diet: Mung bean, 84.3 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent; peanut, previously extracted with ether, 5 per cent. Growth was normal.

3. These curves represent the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 2. Five typical curves only are shown, although ten young lived and grew to normal weight.

4. These curves show the growth of the third generation on the diet that was fed to the animals whose growth is recorded in fig. 2. Inspection of figs. 2, 3, and 4 shows that the rate of reproduction was greatly improved by the addition of 5 per cent of peanut. Ten of the second generation lived and grew to normal weight. The growth of the second and the third generation on this diet was normal.

5. These curves show the growth of the first generation of mice receiving the following diet: Mung bean, 84.3 per cent; gelatine, 5 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent. Growth was normal.

6. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 5. The addition of 5 per cent of gelatine improved the fertility of the parent mice. The rate of growth of the second generation was normal except in the case of one mouse whose rate of growth was slightly subnormal.

7. These curves show the growth of the first generation of white mice on the following diet: Mung bean, 84.3 per cent; soy bean, with

the fat removed by previous extraction with ether, 5 per cent; a mixture of salts, 3.7 per cent; starch, 2 per cent; butter, 5 per cent.

FIG. 8. These curves are for the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 7. The rate of reproduction was slightly improved by the addition of 5 per cent of fat-free soy bean. Two of the second generation lived, and one of them reached normal weight.

9. These curves show the growth of the first generation of mice on the following diet: Mung bean, 92 per cent; sodium chloride and calcium carbonate, 3 per cent; egg white, 5 per cent. All of the first generation showed normal growth except one mouse, whose growth was slightly subnormal.

10. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 9. The addition of 5 per cent of egg white improved the rate of reproduction. Four of the young lived, and two of them attained normal growth.

11. These curves show the growth of the first generation on the following diet; Red kaoliang, 86 per cent; casein, 5 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. The addition of 5 per cent of casein improved the growth of the first generation on a red-kaoliang diet.

12. These curves represent the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 11. While the addition of 5 per cent of casein improved the rate of reproduction, the six young of the second generation that lived seemed not to be gaining normally and the experiment was stopped.

13. These growth curves are for the first generation of mice on the following diet: Red kaoliang, 86 per cent; peanut, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. The rate of reproduction was low, and none of the second generation survived.

14. These curves show the growth of the first generation of mice on the following diet: Red kaoliang, 86 per cent; soy bean, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. This diet produced only one litter of two mice, neither of which lived.

15. These curves give the growth of the first generation of mice on the following diet: Red kaoliang, 76 per cent; mung bean, 15 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. Two litters of young were born, but only one mouse lived. Since the growth of this mouse was subnormal the experiment was discontinued.

16. These curves show the growth of the first generation of white mice on the following diet: White kaoliang, 86 per cent; casein, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. Growth was normal, and the reproduction was improved by the addition of 5 per cent of casein.

17. These curves show the growth of the second generation of mice on the diet that was fed to the animals whose growth is recorded in fig. 16.
18. These curves give the growth of the first generation of mice on the following diet: White kaoliang, 86 per cent; peanut, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; butter, 5 per cent. The growth of the first generation was excellent, and reproduction was normal.
19. These curves show the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 18. All of the young lived through the period of lactation and were showing good growth at the termination of the experiment.
20. These curves give the growth of the first generation of mice on a diet of white kaoliang, 86 per cent; soy bean, previously extracted with ether, 5 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. Growth was excellent except in the case of one mouse. Reproduction was normal.
21. These curves represent the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 20. All of the young lived through the period of lactation and were showing good subsequent growth at the termination of the experiment. Before the termination of the experiment two litters of the third generation were born. The young of the third generation were showing good growth at the conclusion of the experiment.
22. These curves give the growth of the first generation of mice on a diet of white kaoliang, 76 per cent; mung bean, 15 per cent; a mixture of salts, 4 per cent; and butter, 5 per cent. The growth and the rate of reproduction were normal.
23. These curves give the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 22.
24. These curves give the growth of the third generation on the diet that was fed to the animals whose growth is recorded in fig. 22. Growth was good in both cases.
25. These curves show the growth of the first generation of Chinese white mice on a diet which consisted of only white kaoliang, 50 per cent; and millet, 50 per cent. Growth was good; the addition of the millet improved the birth rate somewhat, but it was still below normal.
26. These curves show the growth of the second generation on the diet that was fed to the animals whose growth is recorded in fig. 25. Three of the second generation lived through the period of lactation and were showing good growth at the termination of the experiment.

CHEMICAL ANALYSES OF THIRTY-SEVEN ORIENTAL FOODS

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SEVEN PLATES

The foods discussed in this article were bought in the native markets of Peking, China. Most of them are unknown to the Occident, although many of them are found in the Philippine Islands and other places in the Orient.

As far as possible we have given the botanical classification, the Chinese characters, the Romanized local name in the Peking dialect and, for those foods found also in the Philippine Islands, the name in the Tagalog dialect.

These foods were analyzed for three main purposes: First, that the hospitals and schools in the Orient might be able to use these tables in working out special diets for the treatment of diseases materially affected by diet; second, that the expense of feeding patients might be appreciably lowered by the use of the native foods instead of the expensive imported canned goods; third, that the Western World might know eastern products and might consider the possibilities of introducing these new foods.

The methods used in the analyses were as follows: The proteins were determined as total nitrogen by the Kjeldahl method, and the percentage obtained multiplied by the factor 6.25.

The carbohydrates were determined by subtracting the sum of the percentages of water, fat, protein, ash, and crude fiber, as calculated on the wet basis, from 100.

The fats were determined as the anhydrous ether extract of the dried substance. The Soxhlet method of extraction was employed.

The ash was obtained by the usual ignition method.

The percentage of water was obtained by determining the loss of weight on drying to constant weight at a temperature of 100° C.

[1] The funds for the part of the work reported in this paper that was done in Peking were provided by the Rockefeller Foundation.

TABLE 1.—*Analyses of thirty-seven oriental foods.*

Analysis No. and Peking name of the food analyzed.	Water.	Fat.		Ash.		Protein.		Carbohydrate (calculated by difference).	Crude fiber.		Fuel value.	
		Dry basis.	Wet basis.	Dry basis.	Wet basis.	Dry basis.	Wet basis.	Wet basis.	Dry basis.	Wet basis.	Calories per pound.	Calories per 100 grams.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*		
1. Chieh ts'ai [a]	85.12	0.63	0.09	8.13	1.21	19.78	2.94	9.46	7.93	1.18	229	50
2. Chieh ts'ai ying	88.55	3.77	0.43	14.36	1.64	28.76	3.29	5.11	8.56	0.98	170	37
3. Chiao pai	91.05	3.35	0.30	6.87	0.61	13.34	1.19	5.84	11.29	1.01	140	31
4. Chi tzu ch'ing	87.61	0.13	0.02	4.44	0.55	78.85	9.77	2.05	-------	-------	215	47
5. Chi tzu huang	48.67	53.03	27.22	3.66	1.88	31.63	16.24	5.99	-------	-------	1,503	331
6. Chi tzu ch'ing	86.45	0.18	0.02	4.22	0.57	85.06	11.53	1.43	-------	-------	236	52
7. Chi tzu huang	51.23	52.89	25.79	3.22	1.57	31.56	15.39	6.02	-------	-------	1,431	315
8. Fan kua	94.49	1.37	0.08	10.63	0.59	11.71	0.65	3.61	10.53	0.58	81	18
9. Hao tzu kan	94.10	2.40	0.14	19.40	1.14	25.79	1.52	2.36	12.54	0.74	76	17
10. Hei lo po	76.96	0.46	0.11	3.78	0.87	10.49	2.24	18.13	6.55	1.51	378	83
11. Hsi hu lu	95.11	1.61	0.08	8.72	0.43	9.22	0.45	3.32	12.47	0.61	72	16
12. Hsi hu lu tzu	3.65	48.52	46.75	5.71	5.50	36.86	35.52	6.76	1.89	1.82	2,656	585
13. Hsiang ch'un	88.06	2.50	0.30	9.30	1.11	37.67	4.50	4.25	14.91	1.78	171	38
14. Huang chi ts'ai tzu	7.38	25.45	23.57	3.67	3.40	19.70	18.25	37.25	10.96	10.15	1,961	432
15. Huang hua ts'ai	85.49	2.77	0.40	5.35	0.78	11.42	1.66	10.44	8.48	1.23	236	52
16. Hung kuo	69.79	2.17	0.66	3.34	1.01	2.43	0.73	25.57	7.42	2.24	505	111
17. Hung tsao	21.32	0.46	0.36	1.60	1.26	2.90	2.28	72.56	2.82	2.22	1,375	303
18. Hu tzu	94.35	2.12	0.12	6.26	0.35	15.79	0.89	3.35	16.64	0.94	82	18
19. Kan lu	77.13	0.33	0.08	4.80	1.10	12.58	2.88	17.99	3.59	0.82	383	84
20. Lao mi	9.05	0.98	0.89	1.44	1.31	7.31	6.65	81.75	0.38	0.35	1,643	362
21. Mien chin	77.10	0.27	0.06	2.36	0.54	79.05	18.10	3.84	1.57	0.36	401	88

22. Nan kua	92.21	0.80	0.06	9.65	0.75	10.45	0.81	5.02	14.76	1.15	108	24
23. Pi ch'i (skin on)	71.19	0.44	0.13	4.10	1.18	5.65	1.63	24.63	4.30	1.24	483	106
24. Pi ch'i (skin off)	78.41	0.26	0.06	4.73	1.02	5.26	1.14	18.62	3.47	0.75	362	80
25. P'ieh lan	91.61	1.14	0.10	10.30	0.86	12.39	1.04	5.52	10.37	0.87	123	27
26. Shan yao	79.84	0.41	0.08	3.89	0.78	8.60	1.73	17.24	1.64	0.33	348	77
27. Ssu kua	93.16	2.20	0.15	10.28	0.70	19.73	1.35	3.98	9.65	0.66	103	23
28. T'ang hsi	22.49	------	------	1.31	1.02	1.02	0.79	75.70	------	------	1,391	306
29. Tung kua	96.53	0.81	0.03	11.31	0.39	11.25	0.39	2.15	14.70	0.51	47	10
30. Tz'u ku (skin on)	74.54	0.60	0.15	5.48	1.40	20.29	5.17	18.11	2.47	0.63	429	94
31. Tz'u ku (skin off)	73.74	0.62	0.16	4.98	1.31	19.04	5.00	19.24	2.09	0.55	447	98
32. Weng ts'ai	93.39	4.38	0.29	21.45	1.42	18.03	1.19	2.60	16.79	1.11	81	18
33. Wo kua	90.54	1.07	0.10	6.41	0.61	16.57	1.57	6.23	10.04	0.95	146	32
34. Wo kua tzu	3.52	49.22	47.49	5.01	4.83	37.28	35.97	6.29	1.97	1.90	2,686	592
35. Wo sun	96.85	1.32	0.04	23.39	0.74	22.97	0.72	1.33	10.16	0.32	39	9
36. Wo sun yeh	93.59	3.42	0.22	13.84	0.89	23.75	1.52	3.08	10.92	0.70	92	20
37. Yu ts'ai	93.18	3.67	0.25	21.32	1.45	27.04	1.84	2.45	12.17	0.83	88	19

[a] These names and the equivalent Chinese characters are shown on page 72.

Crude fiber was determined by the usual method.[2]

The calorie values were calculated by the Atwater and Bryant method as follows:

	Calories per gram.	Calories per pound.
Protein	4.0	1,815
Fat	8.9	4,040
Carbohydrates	4.0	1,818

Peking names of foods analylized and the Chinese characters for each name.

[The serial numbers are the same as those in Table 1.]

1 Chieh ts'ai 芥菜
2 Chieh ts'ai ying 芥菜纓
3 Chiao pai 茭白
4 Chi tzu ch'ing 鷄子青
5 Chi tzu huang 鷄子黃
6 Chi tzu ch'ing 鷄子青
7 Chi tzu huang 鷄子黃
8 Fan kua 番瓜(北京俗名)
9 Hao tzu kan 蒿子杆
10 Hei lo po 黑蘿蔔(北京俗名)
11 Hsi hu lu 西葫蘆
12 Hsi hu lu tzu 西葫蘆籽
13 Hsiang ch'un 香椿
14 Huang chi ts'ai tzu 黃稷菜
15 Huang hua ts'ai 黃花菜
16 Hung kuo 紅果
17 Hung tsao 紅棗
18 Hu tzu 瓠子
19 Kan lu 甘露
20 Lao mi 老米
21 Mien chin 麵筋
22 Nan kua 南瓜
23 Pi ch'i (skin on) 荸薺(帶皮)
24 Pi ch'i (skin off) 荸薺(去皮)
25 P'ieh lan 苤蘭
26 Shan yao 山藥
27 Ssu kua 絲瓜
28 T'ang hsi 糖稀
29 Tung kua 冬瓜
30 Tz'u ku (skin on) 慈菇(帶皮)
31 Tz'u ku (skin off) 慈菇(去皮)
32 Weng ts'ai 蕹菜
33 Wo kua 倭瓜
34 Wo kua tzu 倭瓜籽
35 Wo sun 萵筍
36 Wo sun yeh 萵筍葉
37 Yu ts'ai 油菜

SCIENTIFIC NAMES AND DESCRIPTION OF THE FOODS ANALYZED

1. Chieh ts'ai or ko ta is probably a variety of *Brassica campestris* Linnæus. It is a common food in Peking where the root and the top are both eaten. The lower part is known as chieh ts'ai and the upper part as chieh ts'ai ying. A congee made from this plant is supposed by the Chinese to "expel phlegm and prevent evil effluvia." [3] (See analysis 1; Plate 1, fig. 1.)

2. Chieh ts'ai ying, the leafy top of chieh ts'ai. (See analysis 2; Plate 1, fig. 2.)

3. Chiao pai is probably *Hydropyrum latifolium.* This plant is a tall grass about 5 or 6 feet high. It grows in marshy places.

[2] Leach, A. E., Food Inspection and Analysis. John Wiley & Sons, Inc. (1920) 277.

[3] Stuart, G. A., Chinese Materia Medica. American Presbyterian Mission Press (1911) 478.

The young shoot looks somewhat like a bamboo shoot. It is eaten both raw and cooked and has an agreeable sweetish taste. The central mass of this shoot, the part we analyzed, is also edible; it looks like a child's arm. The seeds, which are nearly an inch long, have a grayish cuticle and a white starchy interior. In times of famine they are often used as a substitute for rice. (See analysis No. 3; Plate 1, figs. 3 and 4.)

4. Chi tzu ch'ing is the local name of the white of ordinary hens' eggs. Hens' eggs bought in the Peking markets are small, weighing usually only about 35 to 37 grams as compared with 58 to 60 grams, the weight of the average hen's egg in the United States. The mean percentage composition of the European hen's egg, according to König, is water, 73.67 per cent; proteins, 12.55 per cent; fat, 12.11 per cent; nitrogen-free substance, 0.55 per cent; and salts, 1.12 per cent. In the dry substance, nitrogen 7.66 per cent and fat 45.99 per cent.

Wood and Merrill give the following analyses: [4]

	H_2O.	Protein.		Fat.	Ash.
		$N \times 6.25$.	By difference.		
White of hen's egg	86.2	12.3	13.0	0.2	0.6
Yolk of hen's egg	49.5	15.7	16.1	33.3	1.1

5. Chi tzu huang, the yolk of hen's egg. Analyses 4 and 5 are the white and the yolk, respectively, of the same Peking hen's egg.

6. White of hen's egg.

7. Yolk of hen's egg. Analyses 6 and 7 are the analyses of the white and the yolk of another Chinese egg.

8. Fan kua, perhaps a variety of *Cucurbita maxima* Duchesne. The color of the upper part of the exterior is green and white. The color of the lower part is green and yellow. The color of the meat is cream. This melonlike vegetable is large, and measures 24 inches around the middle. (See analysis 8; Plate 2, figs. 1 to 4.)

9. Hao tzu kan, *Chrysanthemum coronarium* Linnæus, is a highly esteemed green leaf vegetable. It is also found in the Manila markets, and is known in the Philippine Islands by the name tañgú. (See analysis 9.)

[4] Leach, A. E., Food Inspection and Analysis. John Wiley & Sons, Inc. (1920) 267–269.

10. Hei lo po or tzu ta ken, probably *Arctium lappa*, seems to be a variety of edible burdock. It is almost black outside and the meat is purplish white. (See analysis 10; Plate 1, figs. 5 and 6.)

11. Hsi hu lu, perhaps a variety of *Cucurbita pepo* Linnæus, appears to be a kind of vegetable marrow. The exterior shows a smooth skin of dark green. The color of the meat is yellow. It is rather large, the circumference lengthwise measures 24 inches and around the middle 17 inches. (See analysis 11; Plate 3, figs. 1 to 4.)

12. Hsi hu lu tzu, the seeds of hsi hu lu. In China most feasts start with watermelon seeds, or some other seed of a like nature. The seeds of the hsi hu lu are also dried and used as a food. (See analysis 12.)

13. Hsiang ch'un, probably *Cedrela sinensis*, is the leaf of a tree found in the vicinity of Peking. The wood of this tree resembles mahogany and is used in cabinet work. In the spring the boiled tender leaves are used as a food. They are much liked on account of their fragrant odor. They are often used for medicinal purposes in China and are regarded as carminative and corrective. A feeding experiment on white rats, which will be reported in another place, shows that when the food is concentrated by drying and when the dried food is added to a complete diet a strong toxic principle present in hsiang ch'un causes violent convulsions and death. (See analysis 13.)

14. Huang chi ts'ai tzu or huang hsu ts'ai tzu, translated literally, means "yellow-grain vegetable seeds," and is unidentified scientifically. It is a sort of small black seed used as a food. These seeds are said to come from a plant that grows abundantly on the dry alkaline soil along the coastal plain of Chihli Province in China, where almost nothing else grows. The plant is from 6 inches to 2 feet in height. It has green leaves and yellow blossoms which the inhabitants are forced to use as a means for subsistence, both for themselves and for their animals. The small black seeds are more valuable than the leaves and blossoms, and when mixed with flour, are used as a higher-class food. We analyzed the seed only. (See analysis 14; Plate 2, fig. 5.)

15. Huang hua ts'ai, *Hemerocallis fulva*, are dried yellow flowers that are used as a food. The Filipino market name is bulaklak nang saging, because it is erroneously supposed to have some connection with the banana. (See analysis 15; Plate 2, fig. 6.)

16. Hung kuo, perhaps *Mespilus cuneata* Siebold and Zuccarini, is a small round red acrid fruit. It is often dipped into a sugar sirup and mounted on sticks, and is sold commonly on the streets of Peking as a confection. (See analysis 16.)

17. Hung tsao, probably *Zizyphus vulgaris*, are the reddish black seeds of a plant that grows to the height of several feet. These seeds when steamed are used as a food. They are also said to have some medicinal value, being reputed to relieve thirst and fever. (See analysis 17.)

18. Hu tzu, *Lagenaria vulgaris* Seringe, is a slender variety of gourd-shaped vegetable belonging to the same family as the Philippine upo. Its color is green. The meat is white. Its length is about 30 inches and its diameter about 2 inches. (See analysis 18; Plate 3, figs. 5 and 6.)

19. Kan lu, not identified; perhaps *Stachys sieboldi* Miguel. A vegetable found in the Peking market, analyzed shortly before our departure. We have found no similar vegetable in the Manila markets, and on account of insufficient information brought with us from China have been unable to identify it more completely. (See analysis 19.)

20. Lao mi, or *Oryza sativa* Linnæus, is a kind of fermented rice. During the Manchu régime large quantities of rice were brought to Peking for the use of the Manchu population, all of whom were under Government pension. The rice was stored away in large warehouses. It is said that after a certain period of storage, the rice became very hot. It was probably undergoing some sort of fermentation. After five years it became purple. At this stage it became known as lao mi, or old rice. It is considered a delicacy, having a peculiar flavor quite different from that of ordinary rice. (See analysis 20; Plate 5, fig. 4.)

21. Mien chin, a preparation made from wheat flour by several methods. One of the commonest procedures is as follows: Wheat flour is mixed with a dilute salt solution to form a thick paste. The paste is set aside in a cold place for about twenty minutes. After it is well coagulated, it is washed through a bamboo sieve with cold water. The sticky part that remains on the sieve is called mien chin. From its high protein content, this glutinous food is valuable as a meat substitute in the Chinese diet. (See analysis 21.)

22. Nan kua, probably a variety of *Cucurbita maxima* Duchesne, or of *C. pepo* Linnæus, is a large round white vegetable. The meat also is white. (See analysis 22; Plate 4, figs. 3 to 6.)

23. Pi ch'i, *Eleocharis tuberosa,* is a plant that grows in shallow water. The tubers are black externally. They are sometimes called ground chestnut or water chestnut because they somewhat resemble the chestnut in appearance although not at all in flavor. The plant has been imported from China to the Philippine Islands, where it is known as apulid tsina. The tubers are eaten both raw and cooked. Analyses were made of the tubers with and without the outer skin. (For analysis of pi ch'i with the skin on, see analysis 23; Plate 5, figs. 1 to 3.)

24. Pi ch'i, analysis was made with the outer skin removed. (See analysis 24.)

25. P'ieh lan, apparently a variety of *Brassica campestris* Linnaeus, seems to be a sort of kohl-rabi. The exterior is pale green and is smooth except for a few circular ridges. The color of the meat is white. The edible portion grows above ground. (See analysis 25; Plate 6, figs. 1 to 4.)

26. Shan yao, *Dioscorea batatas* Decaisne, is a plant somewhat like the potato. It resembles the potato in color but has short stiff hairs, about one-eighth of an inch long, on its surface. There are enzymes present which darken the cut portion in the presence of air. (See analysis 26; Plate 3, figs. 7 and 8.)

27. Ssu kua, *Luffa cylindrica* (Linnæus) M. Roemer, is perhaps a slender form of the Filipino kastila. It is of a mottled green color and has lengthwise ridges. (See analysis 27; Plate 5, figs. 5 to 8.)

28. T'ang hsi is a sweetish sirup widely used in North China. As nearly as we could ascertain, the food is prepared as follows: Barley is sprouted in a willow vessel until it is about a half inch long and then it is ground fine. Millet is steamed, mixed with an equal portion of the sprouted barley, and the mixture is moistened. This mixture is allowed to ferment in a warm place, and after fermentation is poured into hot water to digest at 70 to 80° C. for about six or eight hours. The juice is filtered through a mat and transferred to a large boiler where it is concentrated while being stirred frequently, in order that it may be brought to the proper consistency without charring. This thick sirup is much appreciated by the Chinese. (See analysis 28.)

29. Tung kua, *Benincasa hispida* Cogniaux, is the kondol of the Philippine Islands. In the Philippine Islands it is also called tan kua or seikey. It is used as a vegetable or, when preserved with sugar, as a sweetmeat. The seeds are believed by the Chinese to have medicinal value, and a famous prescription calls

for the use of these seeds incinerated and taken internally for the treatment of gonorrhœa. The pulp of this gourd is considered by the Chinese to be a diuretic, and is used in the treatment of gravel. The Chinese also add it to baths for the treatment of prickly heat.[5] (See analysis 29; Plate 7, figs. 5 to 7.)

30. Tz'u ku, *Sagittaria sagittifolia* Linnæus, is a tuber that grows in shallow water. In the fall and early spring the tubers are dug up and cooked for food. This plant is not now grown commonly in the Philippine Islands, but has succeeded very well in the garden of a Filipino botanist in Manila. A sort of arrowroot is sometimes made from the tender stalk. We analyzed the tubers only, both with and without the outside skin. (For analysis of tz'u ku with skin, see analysis 30; Plate 7, figs. 1 to 3.)

31. Tz'u ku was also analyzed without the skin. (See analysis 31.)

32. Weng ts' ai, *Ipomoea reptans* Poiret, is a green leaf vegetable probably identical with the Filipino kangkong or tankong. The green resembles spinach in flavor. (See analysis 32.)

33. Wo kua, probably a variety of *Cucurbita pepo* Linnæus, is one of the numerous squashlike vegetables found in Peking. The color of the exterior is medium green with yellow spots. The meat is orange colored. The vegetable and the seeds were both analyzed. In Manila a similar vegetable is called kalabasang pula. (For analysis of the vegetable see analysis 33; Plate 6, figs. 5 to 8.)

34. Wo kua yeh, the seeds of wo kua, were also analyzed. Melon and squash seeds are a popular food in the Chinese diet. (For analysis of the wo kua seeds see analysis 34.)

35. Wo sun, perhaps a variety of *Lactuca sativa* Linnæus, is a lettuce-root sort of vegetable, but it also has some characteristics of a *Brassica*. The color of the outside of the stalk is pale green. It is about 10 inches in length. The edible portion grows above the ground. The root, wo sun, and the leaves, wo sun yeh, were both analyzed, since both are used as foods. Analysis 35 is the analysis of wo sun. (See Plate 4, figs. 1 and 2.)

36. Wo sun yeh, the leafy part of wo sun, analysis 36.

37. Yu ts'ai, *Brassica rapa* Linnæus, is one of the numerous green vegetables found in the markets of Peking. From the seeds of this plant is expressed the oil known as rape-seed oil,

[5] Stuart, G. A., Chinese Materia Medica. American Presbyterian Mission Press (1911) 67.

ts'ai yu. Until the introduction of kerosene, rape oil was used in China as an illuminant, and it is still used for culinary purposes. The green part is eaten in the spring, and this is the part we analyzed. The Chinese believe that the juice expressed from the stalk and the leaves of this plant is of medicinal importance. They give it in dysentery, and also apply this juice to sores, caked breast, cancer, etc. (See analysis 37; Plate 7, fig. 4.)

ILLUSTRATIONS

PLATE 1

FIG. 1. Chieh ts'ai ying, exterior.
2. Chieh ts'ai ying, cut to show interior.
3. Chaio pai, exterior.
4. Chaio pai, edible central portion.
5. Hei lo po, exterior.
6. Hei lo po, cut to show interior.

PLATE 2

FIGS. 1 to 3. Fan kua, exterior, three views.
FIG. 4. Fan kua, cut to show interior.
5. Huang chi ts'ai tzu.
6. Huang hua ts'ai, two views.

PLATE 3

FIGS. 1 to 3. Hsi hu lu, exterior, three views.
FIG. 4. Hsi hu lu, cut to show interior.
5. Hu tzu, exterior.
6. Hu tzu, cut to show interior.
7. Shan yao, exterior.
8. Shan yao, cut to show interior.

PLATE 4

FIG. 1. Wo sun, exterior.
2. Wo sun, cut to show interior.
FIGS. 3 to 5. Nan kua, exterior, three views.
FIG. 6. Nan kua, cut to show interior.

PLATE 5

FIGS. 1 to 3. Pi ch'i, exterior, three views.
FIG. 4. Lao mi.
FIGS. 5 and 6. Ssu kua, exterior, two views.
7 and 8. Ssu kua, cut to show interior, two views.

PLATE 6

FIGS. 1 to 3. P'ieh lan, exterior, three views.
FIG. 4. P'ieh lan, cut to show interior.
FIGS. 5 to 7. Wo kua, exterior, three views.
FIG. 8. Wo kua, cut to show interior.

PLATE 7

FIGS. 1 and 2. Tz'u ku, exterior, two views.
FIG. 3. Tz'u ku, cut to show interior.
4. Yu ts'ai, exterior.
FIGS. 5 and 6. Tung kua, exterior, two views.
FIG. 7. Tung kua, cut to show interior.

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PLATE 1.

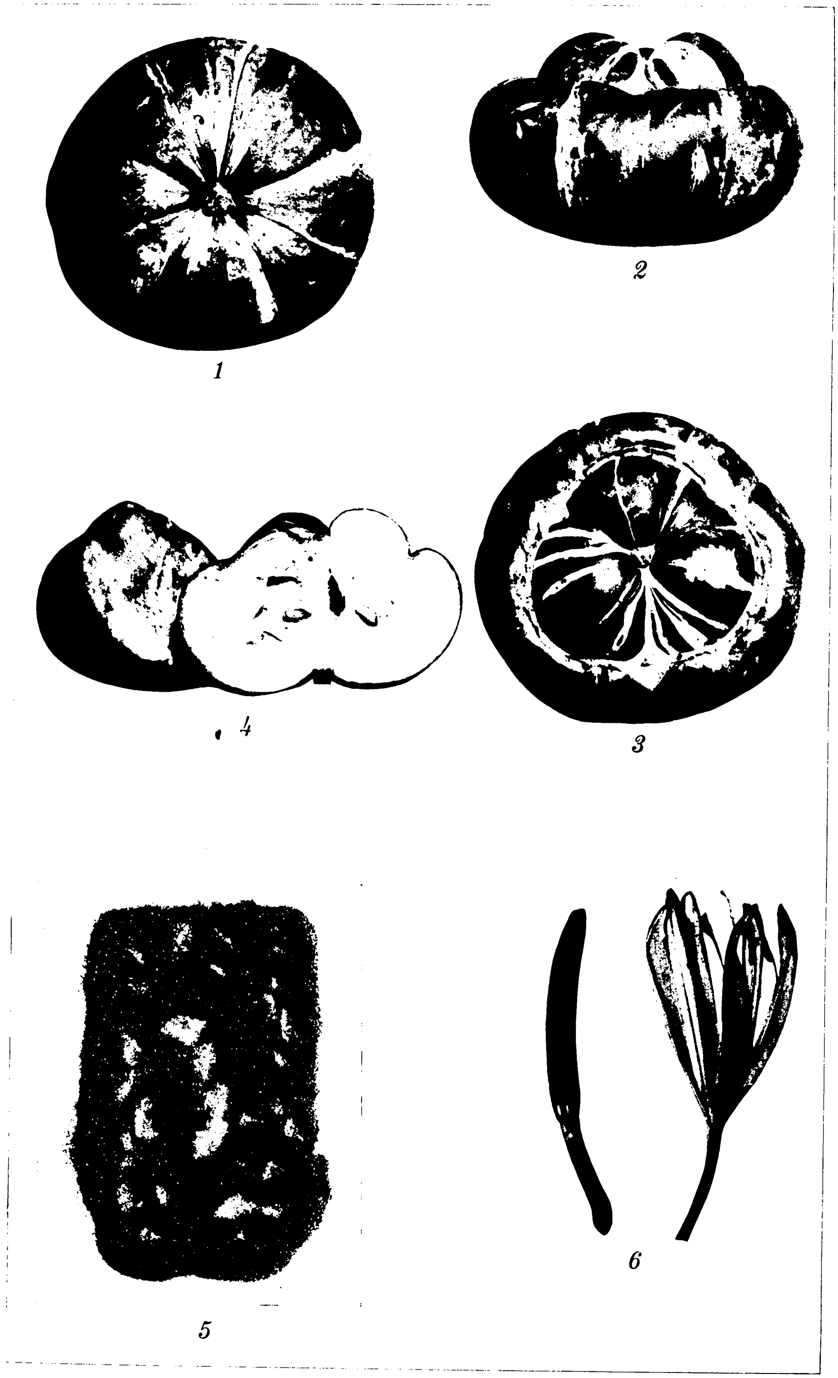

PLATE 2.

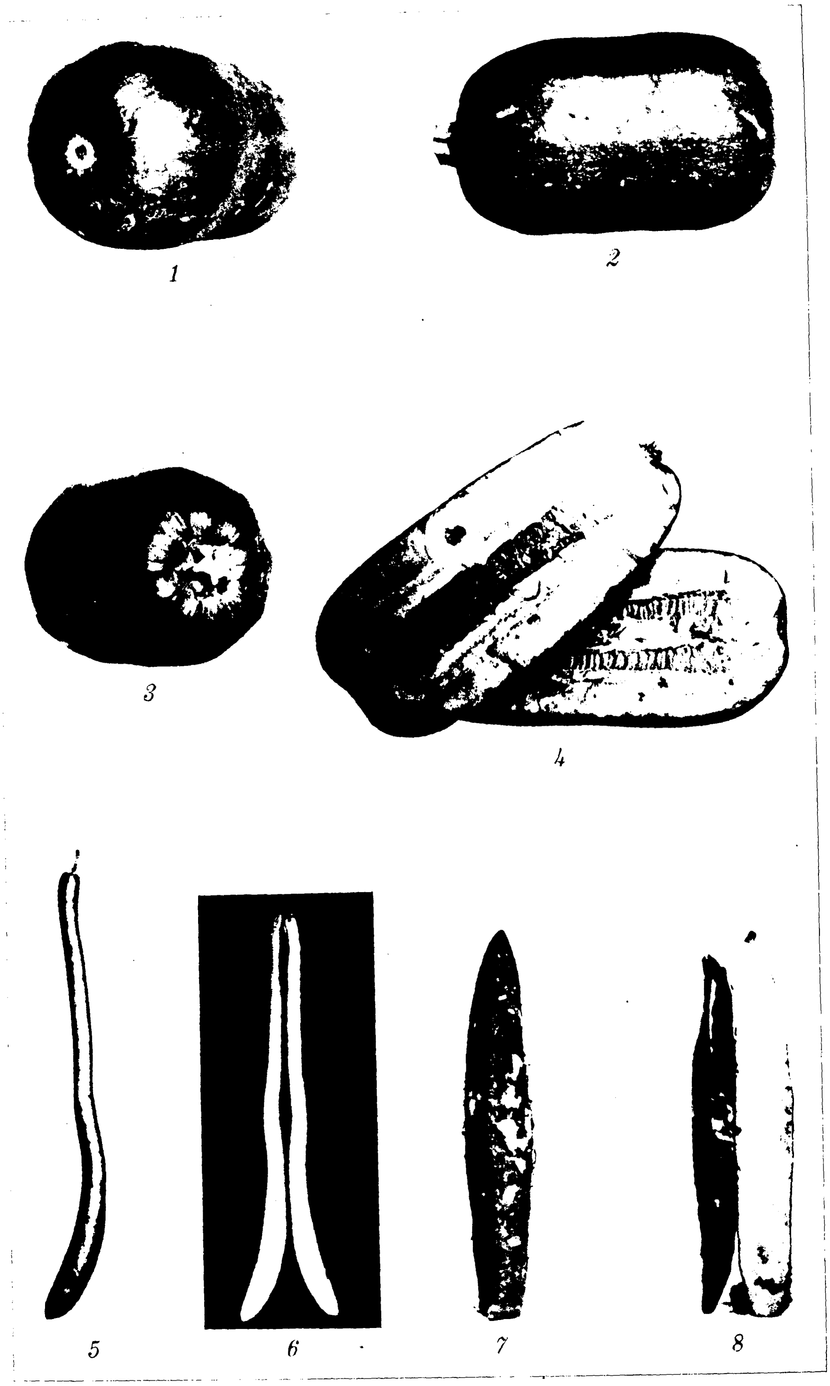

PLATE 3.

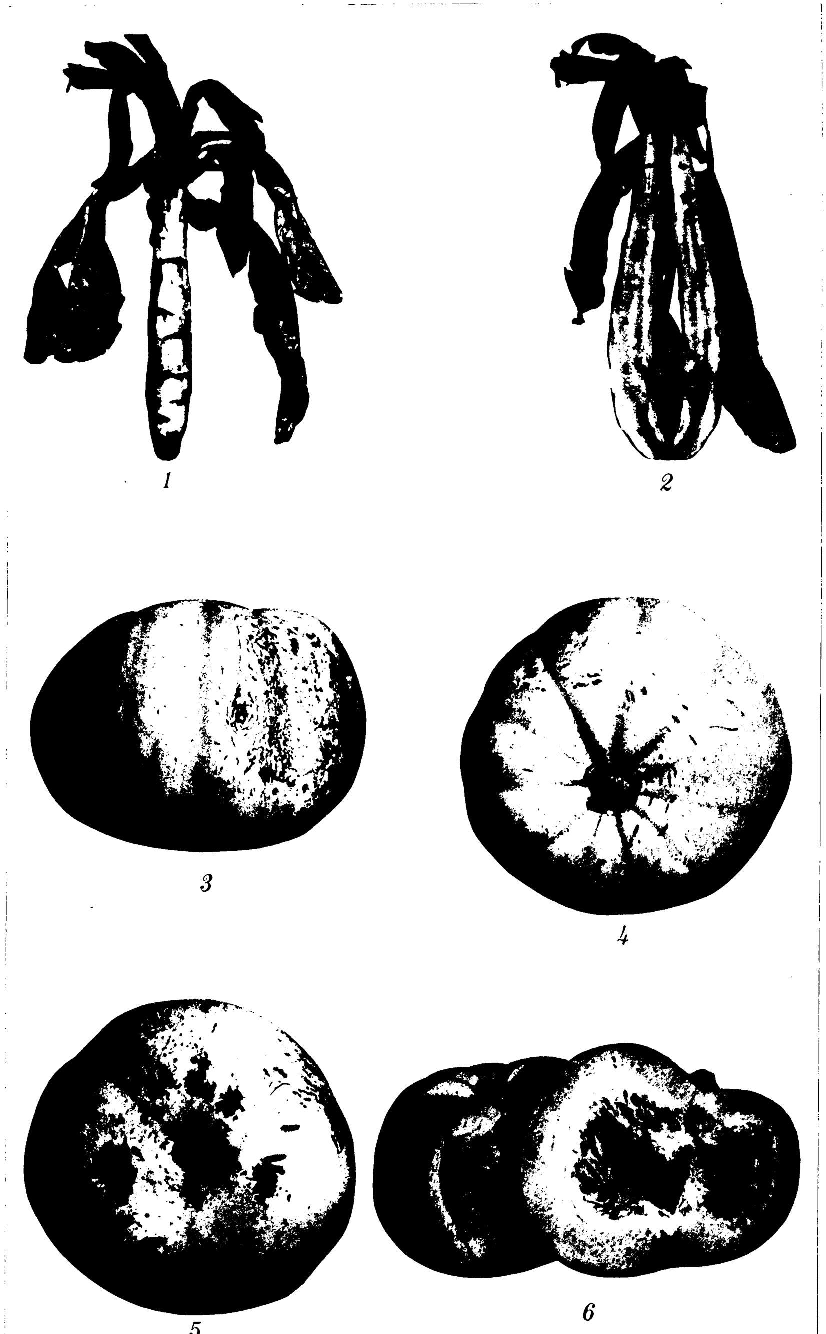

PLATE 4.

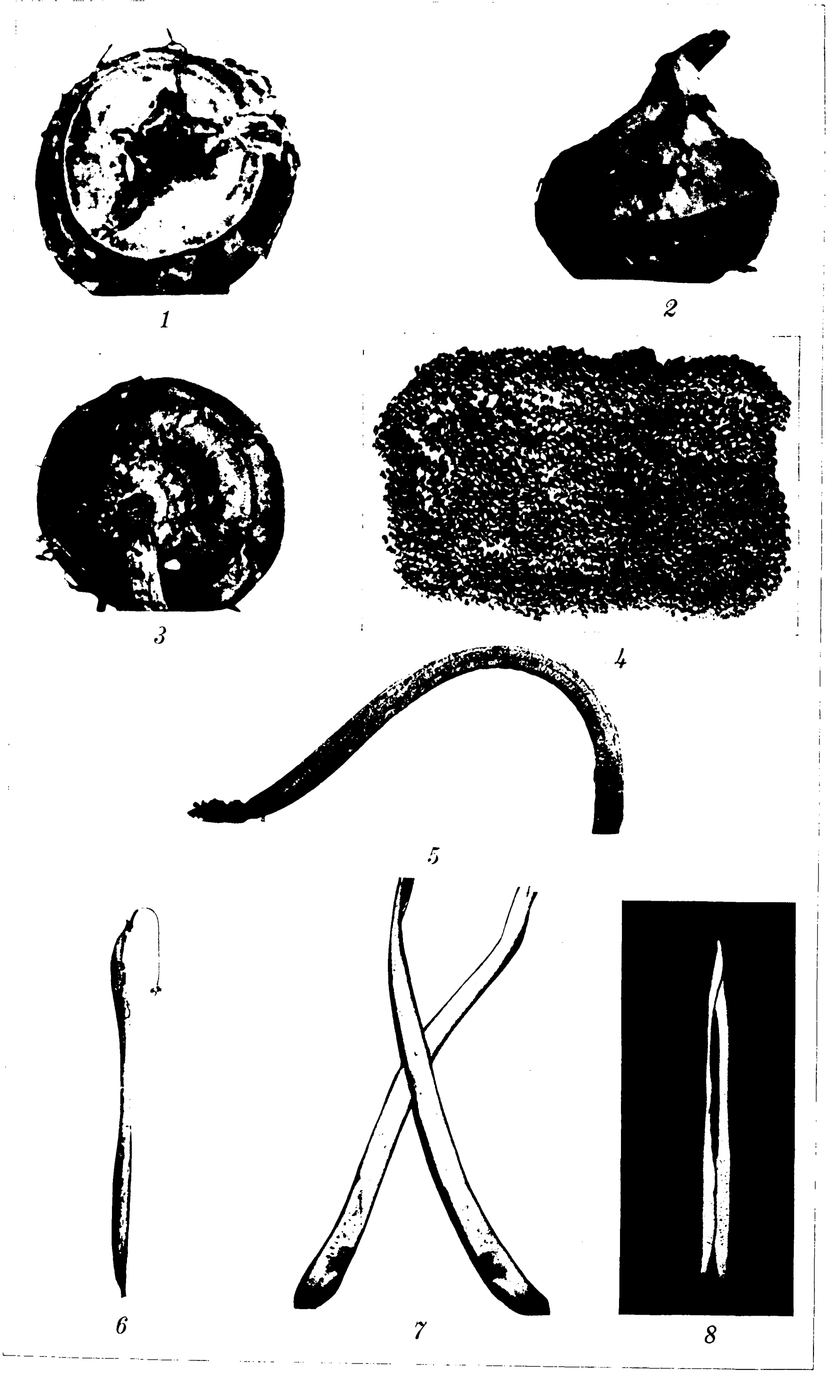

PLATE 5.

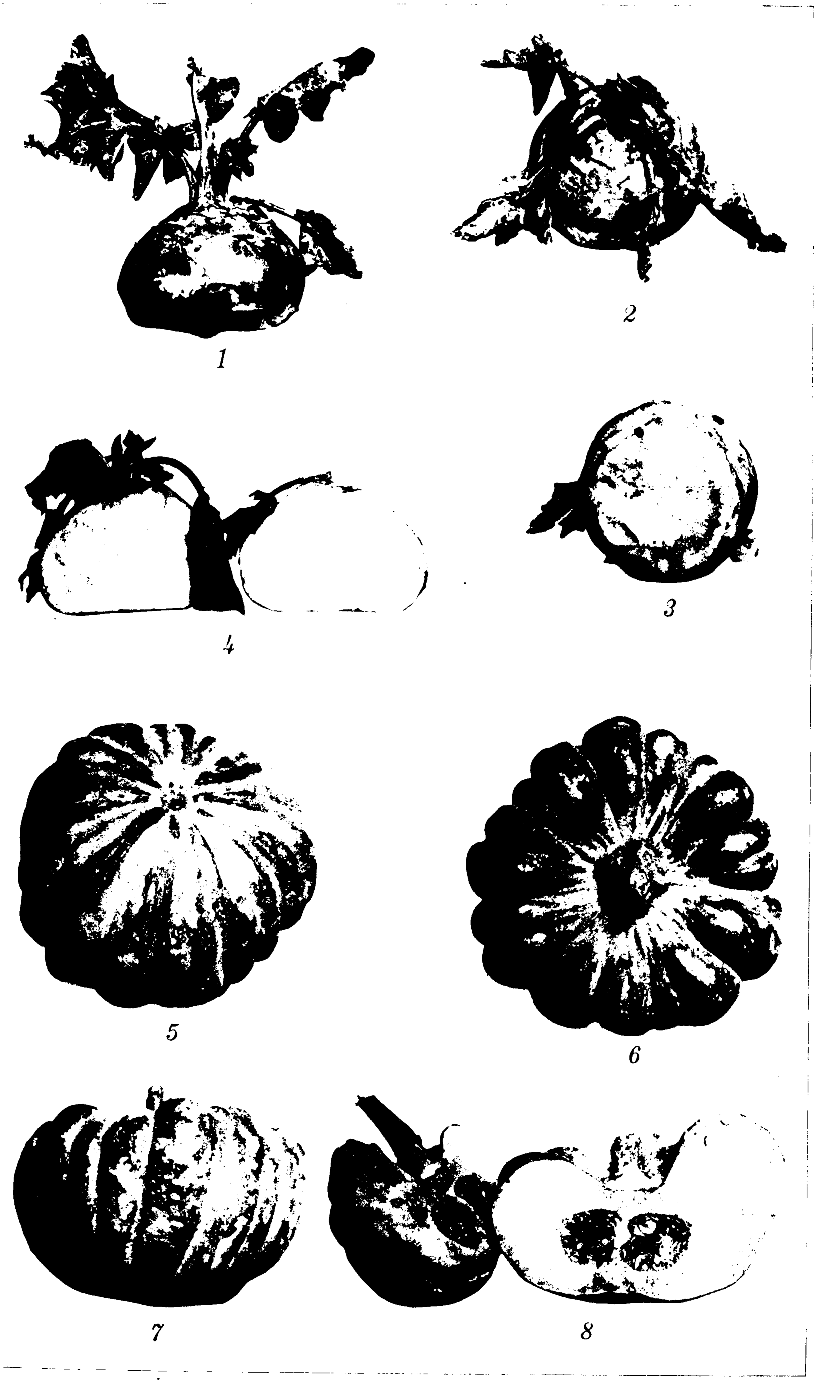

PLATE 6.

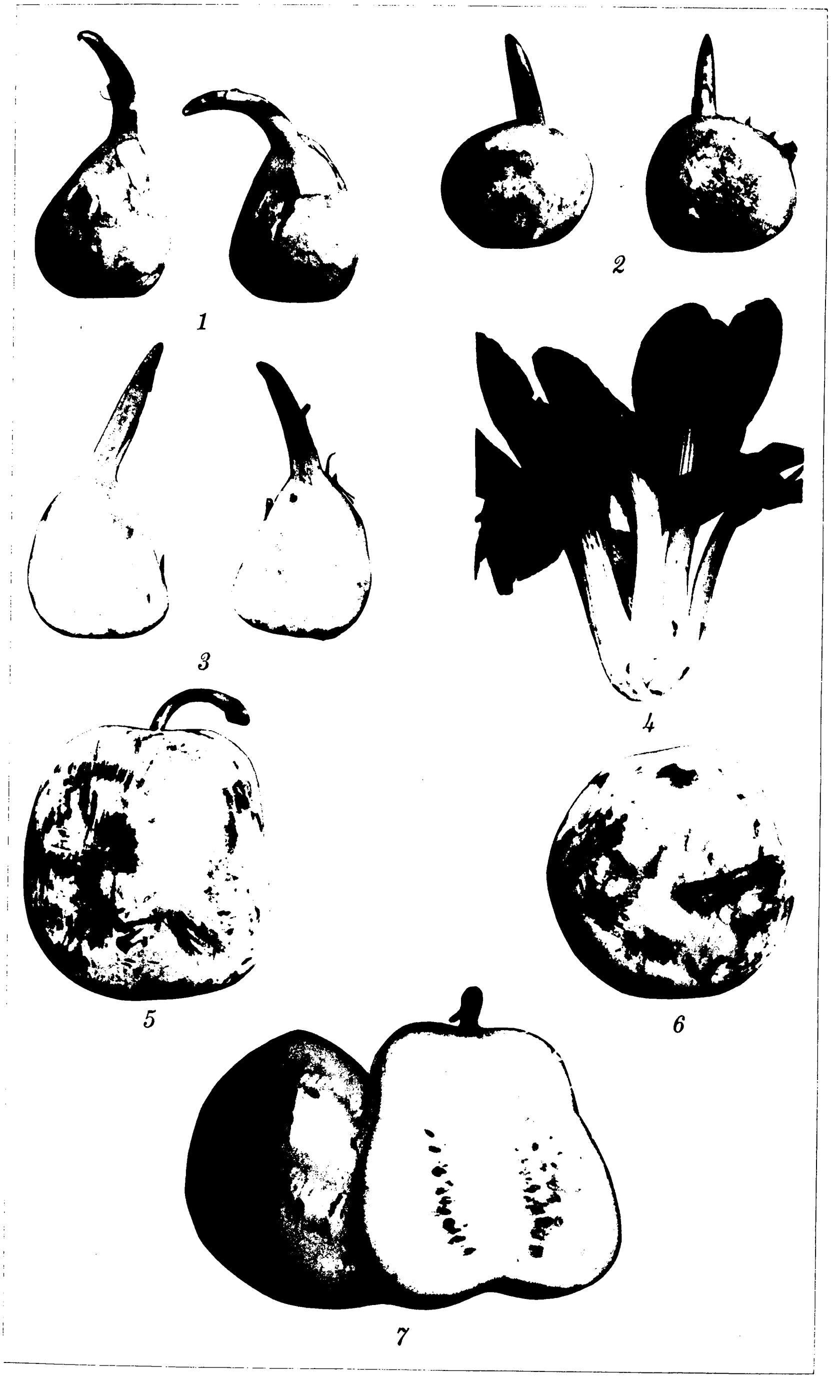

PLATE 7.

CALCIUM, IRON, AND MAGNESIUM CONTENT OF SIXTEEN CHINESE FOODS

By HARTLEY EMBREY SHERMAN and TSAN CH'ING WANG

Of the Laboratories of Food Chemistry, Peking Union Medical College Peking, China, and the Bureau of Science, Manila [1]

In view of the constantly increasing importance that is being attached by food experts to the presence of small quantities of certain minerals found in foods, sixteen common food substances were purchased in the Peking markets and analyzed for mineral content.

TABLE 1.—*Percentage of iron and aluminum, calcium, and magnesium in the ash of sixteen Chinese foods.*

Analysis No.	Name of food.	Aluminum (Al) and iron (Fe) calculated as aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3).	Calcium (Ca) calculated as calcium oxide (CaO).	Magnesium (Mg) calculated as magnesium oxide (MgO).
1	Huang tou	0.49	7.45	7.34
2	Huang tou ya [a]	0.43	10.96	8.63
3	do [b]	0.33	7.53	8.25
4	Green bean	0.62	9.31	7.41
5	Green-bean sprout (in hydrant water)	0.41	11.14	8.50
6	Green-bean sprout (in distilled water)	0.44	8.25	8.14
7	Mung bean	0.59	5.16	8.33
8	Mung-bean sprout (in hydrant water)	0.32	8.89	9.51
9	Mung-bean sprout (in distilled water)	0.45	3.39	7.32
10	Hsiang ch'un	2.59	15.72	5.36
11	Chiao pai	0.16	1.05	2.35
12	Tz'u ku	0.12	1.74	3.48
13	Yu ts'ai	0.68	13.56	5.59
14	Hao tzu kan	0.76	9.92	4.08
15	Hung kaoliang	1.64	2.42	13.17
16	Pai kaoliang	2.77	9.97	7.16
17	P'ieh lan	0.13	9.55	3.71
18	Hsi hu lu	0.14	4.50	4.33
19	Wo kua	0.09	5.27	3.38

[a] Yellow soy bean, sprouted in Peking hydrant water.

[b] Some of the same lot of yellow soy beans, sprouted in distilled water.

The methods used for these analyses are the usual ones as given by Leach.[1]

The scientific names and the descriptions of all the foods mentioned in this paper, with only two exceptions, are found in the preceding paper on the chemical analyses of thirty-seven oriental foods. The two foods not described in the above paper, pai kaoliang and kung kaoliang, have been described elsewhere.[2]

All of the sprouts in distilled water have a lower calcium content than the same kind of sprout grown in the notably hard water of Peking. This part of the analytical work was done in order to gain some idea of the degree of variation in mineral content one might expect when the same food is grown under different soil conditions. Since the soil around Peking is rich in lime, probably all the foods analyzed show a somewhat higher calcium content than the same food substances grown elsewhere in a different type of soil.

[1] Leach, A. E., Food Inspection and Analysis. John Wiley & Sons, Inc. (1920) 311.

[2] Embrey, Hartley, and T. C. Wang, China Med. Journ. **35** (1921) 247.

A STUDY ON THE CRANIAL CAPACITY OF FILIPINOS

By JUAN C. NAÑAGAS

Of the College of Medicine, University of the Philippines, Manila

THREE PLATES AND FIVE TEXT FIGURES

INTRODUCTORY REMARKS

There exists a wide general desire to understand more accurately the various racial characteristics of the Malays; to know in a more-detailed degree the anthropometric condition and structural development of the different groups of the brown race and to understand more particularly the characteristics that are inherent in one of their more-advanced groups, represented, we believe, by the Filipinos. The last objective is specially aimed at in our local institution for the beneficent purpose of devising and adopting measures that will help further to improve the physical development of the race. In recent years there has been some interest in the study of the ethnographic and anthropogenic history of the Filipinos and of such problems as revolve upon the ever-perplexing question of supposed correlation of racial potentialities, mental or physical, with the state of body development, the size of the head, or the volume of the brain case.

The writer has been asked many times about the weight of the brain, or the size of the head, or the volume of the cranial contents of Filipinos. These inquiries come from foreigners and Filipinos alike, and equally from scientists, professionals, and laymen. We hope that the present study will satisfy, to some extent, the seemingly long-felt want of knowing at least one of those characteristics.

We are rather fortunate that within six years the Department of Anatomy of the University of the Philippines has been able to collect and carefully prepare around six hundred crania from cases that possess definite histories and clinical records. Therefore, the present work is based on a fair number of known cases of Filipino skulls. This paper is intended to serve as an opening report, to be followed by other work on craniometry, which will be based on the same collection of skulls.

It is unfortunate that we cannot give a historical sketch of the study of Filipino crania. We have carefully searched for literature available locally on the subject, dealing with Filipinos or the Malay race, and we found very few reports on the cranial capacity of the race. Past work comprised isolated reports, each covering only one or few cases and dealing mainly with general anthropologic or ethnographic points, rather than with the dimentional characteristics. The craniometric points considered, besides being general in nature, were not based on carefully studied methods and technic. Such lack of uniformity in statistical procedure certainly does not permit a fair comparison of the results obtained in the past with those derived from the present work. In view of the above objections and difficulties, no review of literature is included in this paper.

MATERIAL FOR THE PRESENT STUDY

The cranial material was collected from cases sent to the morgue of the City of Manila that were not claimed by the families. They were received from the various districts of the city, not only from the various hospitals but also from all public-welfare institutions of the Government. Soon after the proper official permit is obtained, the head is removed from the body and all the soft tissues are dissected out. The brain substance and the meninges are then removed piecemeal through the foramen magnum. The sawing-off of the skull cap from the rest of the cranium for the purpose of removing the cranial contents was never resorted to in any of our series, in order to preserve the integrity of the skull. For this reason the brain tissues are removed as thoroughly as possible through the foramen magnum. The striped skull is then boiled in water to soften and eventually take away all the remaining soft tissues. The addition of Gold Dust powder was found to hasten the softening of adherent tissues. The boiling is continued for about twelve hours, until the bone is entirely free from attached ligaments and periosteum. The skull is thoroughly washed in tap water and is then allowed to remain immersed in running water for seven days. It is again carefully washed, and the cranial cavity finally inspected and cleaned. The specimen is then dried in the sun, and exposed to direct sunlight for about three more days, or until the skull is properly dried and fairly bleached.

The above method of preparation is rather tedious and consumes much attention and labor, but it was found to give in our

hands the best result as compared with various other methods that we have tried. A skull so prepared is not surpassed in strength, cleanliness, and whiteness by specimens obtained under other procedures that do not employ chemicals for cleaning and whitening the bone.

The number of skulls prepared in this manner exceeds the actual number used in the present study. This is due to the fact that we have some crania of the collection assigned or distributed to several institutions in the Islands for instructional purposes, and these we failed to include in this series that we are reporting. This work includes altogether four hundred and thirty-six cases. Each of these skulls was thoroughly and carefully measured by two members of our departmental staff, Doctors Cuajunco and Encarnacion, whose persistent interest and painstaking attention in making careful and uniform measurements, have made possible the present paper.

The institutions in Manila that have contributed to the present collection are the following:

	Skulls.
Bilibid Prison	389
City hospitals	32
Other places in the City of Manila	10
City asylums	5

It will be noticed that a great majority of the cases came from the Government penitentiary; this is because most of the pauper cases, unclaimed by families, came from that institution. These prisoners were gathered from different parts of the Islands for long terms of confinement in the central penitentiary. This incidence might be interpreted to carry considerable significance by criminologists; however, the facts and findings from this study will be reported without discussing such a complex and complicated question. This undesirable incidence of this series cannot be helped, nevertheless it cannot be denied that all the cases belong to the same race. Whatever unfavorable and critical interpretations may be given to our findings, because of this peculiar feature, should be welcomed; they may be of help in elucidating certain questions of criminological interest. Because of the relatively small size of the present collection, the writer does not consider and will not claim that his results are typical or settled standards for Filipinos, and precisely because of this fact the title of this article is "a study on the cranial capacity of Filipinos."

The average age of this series of crania is 41 years. The age distribution of the cases is shown in Table 1 and in fig. 1.

TABLE 1.—*Age-frequency table of cases.*

Age limits.	Frequency.	Percentage.	Age limits.	Frequency.	Percentage.
Years.			*Years.*		
15–20	21	4.82	61– 65	28	6.42
21–25	45	10.32	66– 70	7	1.60
26–30	60	13.76	71– 75	6	1.38
31–35	70	16.06	76– 80	5	1.15
36–40	57	13.07	81– 85	2	0.46
41–45	41	9.40	86– 90	2	0.46
46–50	43	9.86	91– 95	5	1.15
51–55	16	3.67	96–100	1	0.23
56–60	27	6.19			
			Total	436	100

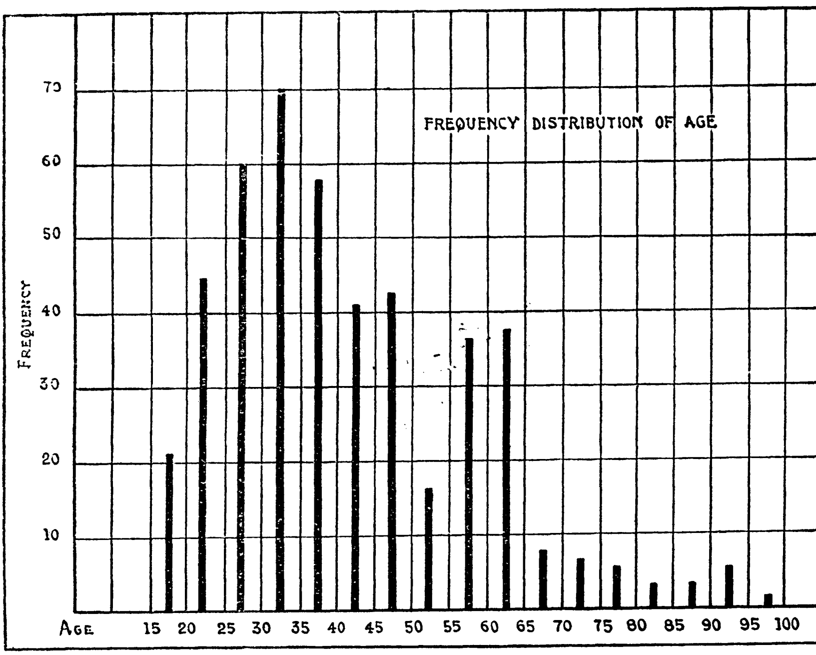

FIG. 1. Curve of age distribution.

From the age-frequency table and the corresponding graph it is seen that about 30 per cent of the cases are between the ages of 26 and 35 years, and that a little over 53 per cent of the series are between the ages of 21 and 40 years. It is fair to conclude, therefore, that this series belongs to the adult, or mature, group of the population.

The geographic distribution of all the cases we have studied in this work is given in Table 2 and in the circular diagram, fig. 2.

TABLE 2.—*Geographic distribution of cases.*

Region of the Philippines.	Frequency.	Percentage.
City of Manila	29	6.65
Ilocano provinces	53	12.16
Pampanga and Pangasinan Provinces	38	8.71
Tagalog provinces	92	21.10
Bicol provinces	27	6.19
Eastern Visayan provinces	102	23.39
Western Visayan provinces	61	14.00
Mindanao and Palawan Province	21	4.82
Undetermined cases	13	2.98
Total	436	100

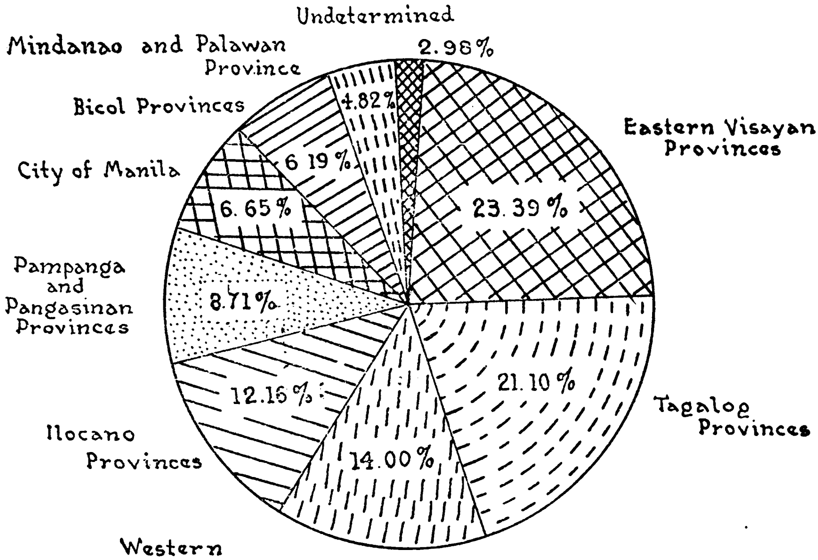

FIG. 2. A circle diagram illustrating the geographic distribution of cases under study.

The geographic groups that are most represented in this series, as distinctly demonstrated in fig. 2, are the eastern Visayan and the Tagalog provinces, comprising more than 20 per cent of the cases for each group. The next two regions showing a representation of over 10 per cent are the western Visayan and the Ilocano provinces. It appears that the representation in this series of the various provinces is in direct relation or proportion

to the degree of the actual density of population of the various regions of the Islands, as borne out by the Philippine Census of 1918. We are glad to note that such a correlation occurs in this report, as it enhances the value of this study, because it shows that the provincial groups of our people are well represented in this series of crania.

MEASURING EQUIPMENT AND TECHNIC

The direct determination of cranial capacity, or the direct measurement of cubage of the cranial vault, has been employed for over a century and a half. It was Soemmering who first attempted to measure the capacity of the cranial vault with water in the year 1785. Since then many varieties of technic have been devised—some simple, others more-complicated procedures, either in the materials employed or the mechanical devices used; or in the matter of personal equation and individual errors possible during measurements, and even in the mathematical calculations resorted to—to make the results fairly uniform and comparable. Because of certain obvious drawbacks in employing water to measure the cranial capacity of dried skulls, other materials have been introduced by various investigators. Sand was first used in 1831 by Hamilton. Tiedmann in 1837 introduced the use of millet which soon was substituted by pepper seeds in 1839, and then by shot in 1849 as first employed by Morton. Broca later introduced the standardization of the use of shot, and with his critical and careful investigations he contributed one of the best standard works on the study of cranial capacity. Broca's studies were begun in 1861 and were responsible for creating a much more enthusiastic attitude towards the investigation of problems on craniometry. Other materials have since been employed, such as, vegetable grains, glass beads, aluminum shot, rubber bags, pig's bladders, plaster casts, and mercury—all of which have been used as accessories in determining the cranial capacity by the so-called direct method.

In the beginning of the nineteenth century students commenced to follow similar investigations upon what was referred to as "green skull." The skull used was fresh from the cadaver, with the dura mater left intact, instead of the "dry skulls" employed by earlier observers. This was originated by Zanka in 1897 and followed by Pfister, Reichert, and Vitali in later years. The latest work regarding this method was that of Todd, in 1923, who carefully employed the water method on green skulls of cadavers in measuring cranial capacity.

The description of the technic of the various types of determination of cranial capacity are well given in a historical sketch by Todd and in synoptic form in the publications of Martin and of Hrdlička. The details of methods and the mathematical procedures in working out the problem are given in the two former publications, and the details of the necessary measurements and the mistakes and the errors that may be committed or encountered in the process and the devices recommended to minimize them are explained in the publications of the last author.

It is almost proverbial in works on craniometry that each author, when submitting the result of his work, considers his method and technic as the optimum, and even tries to present his results in the best light possible to prove his contention. Under these conditions, it is difficult to make a choice of the best method to follow. The great variety of technic followed by different investigators would not seem to allow an ideal comparison of results, without a certain degree of skepticism. It is, of course, believed that each kind of cranial material will need a certain type of procedure; thus, the green-skull series requires one method, while the dried-skull group requires another.

In our study and choice of technic for the determination of cranial capacity in this series, we deemed it advisable to devise certain modifications of the instruments recommended by Hrdlička as used by Flower for volumetric measurements. Careful attention has been directed towards eliminating, as much as possible, sources of error that were attributable to personal influences in order to reduce, as Hrdlička particularly emphasized, the capacity determination to a mechanical procedure, so as to make it an easy process and to minimize the effect of personal equation on the whole process and on the results.

The measuring equipment that we have used is shown on Plate 1 and is as follows:

One zinc vessel with attached funnel (measuring receptacle).
One wooden stand with a folding platform.
Two graduated cylinders of 2,000 cubic centimeters capacity.
One wooden hammer with rubber pads.
Two wooden ring cushions.
One large enamel tray.
Three glass jars of about 2,500 cubic centimeters capacity each.
Fine sand, 4,000 cubic centimeters.
Mustard seed, 4,000 cubic centimeters.
Shot, size No. 8 of 2.2 millimeters diameter, 4,000 cubic centimeters.
Bronze sieve manufactured by The W. S. Tyler Co., Cleveland, Ohio. Sieve is double crimped with 60 meshes to the inch, and with the opening 0.0087 of an inch.

Adhesive-plaster ribbon 1 inch wide.
One hard-rubber funnel.
One large spoon.
One tin spatula.

The measuring receptacle and attachments that we have devised and constructed consist of a zinc vessel, a four-legged wooden stand, and a folding platform at the middle. The vessel is similar in construction to Flower's and is provided with an attached funnel at the lower end. It is 24 centimeters high, with a diameter of 20 centimeters. The funnel is about 45° dip and contains a circular outlet of 20 millimeters. This outlet is guarded by a traplike arrangement consisting of a movable plate of zinc, so placed that it can be pushed in or pulled out for a distance of 3.5 centimeters in opening and closing, re-

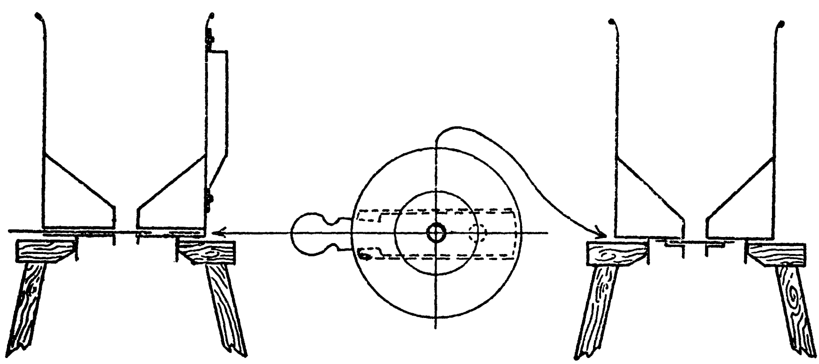

FIG. 3.. Diagramatic sections of the tin receptacle and funnel used in cranial-capacity measurement.

spectively, the funnel outlet with the least possible jar. This sliding plate is closely and snugly fitted at the bottom of the vessel in such a way that, although it allows a sliding movement in one direction, it does not permit the measuring materials to enter the spaces around the sliding plate and interfere with its function. This zinc plate is provided with a circular opening at the middle portion, so placed that on sliding backward it exactly coincides with the outlet of the funnel to release the material contained in the vessel. Cross sections of this part are represented in fig. 3 outlining its rather simple mechanism. The wooden stand that we have devised forms the support of the zinc vessel when measuring. It is high enough to permit placing under it either the skull or the graduated cylinder, below the zinc vessel to receive the measuring material coming from the receptacle. This stand, together with its attached platform,

is found to be of great service in holding the vessel steadily without any appreciable vibration when the cranium or the cylinder is being filled by measuring material. The device minimizes errors in measurement that are attributable to unnecessary motions or vibration from the unsteady support of either the skull or the funnel. The wooden platform is placed at the middle horizontal level of the stand and is here supported with hinges behind and releasable hooks in front. This can thus be folded downward at will to give place for the graduated cylinder. This platform is used for the support of the cranium while it is in position to receive the measuring material from the zinc vessel. The platform is provided with an oval wooden ring that serves as a cushion to help make the skull stand upside down over the platform when receiving the measuring material through the foramen magnum. The height of the whole stand is 56 centimeters, just high enough to accommodate underneath it the graduated cylinder of 2,000 cubic centimeters capacity. The distance of the wooden platform from the lower surface of the zinc vessel is 23 centimeters, leaving enough space between them to hold the skull in place beneath the zinc vessel.

We have used the zinc vessel throughout the whole series of volumetric measurement of the skulls. It has been invariably employed in filling both the skull and the cylinder, whether with or without shaking, and for all the materials that we have employed in the measurements.

To measure the capacity of a skull, about 2 liters of the measuring material are poured into the zinc vessel with its outlet closed. The skull is placed upon the wooden platform, beneath the vessel, and made steady by the oval wooden cushion placed underneath the calvarium. The skull is made to stand with its base directed upward and in the horizontal plane, and the foramen magnum exactly opposite the funnel outlet. When the type of measurement to be followed is without shaking, the cranium is filled carefully with the measuring material by opening the outlet of the funnel; that is, by pushing the traplike device, until the cranial vault is entirely filled. The moment when the vault is nearly filled is closely watched for so as to close the funnel opening synchronously with the complete filling of the cranium. If this is not done accurately, there is either an overflow or a little space on the top is left vacant. In the latter case more of the material is allowed to flow slowly until the vault is completely full, and in the former case the excess is carefully removed by means of a tin spatula. In every instance the measurement that

we consider full is that in which the measuring material reaches to the rim of the foramen magnum. The filled skull is set aside for a while. The material remaining in the vessel is then allowed to flow out completely into a receptacle. The outlet of the funnel is again closed. The contents of the skull just set aside are then poured out completely into the vessel. The graduated cylinder having a capacity of 2,000 cubic centimeters is placed below the vessel with the mouth directly underneath the funnel outlet, the platform in this case is folded down through the release of two side hooks, to accommodate the cylinder. The material in the vessel is then allowed to flow into the cylinder, thus providing for its passage through the same outlet and subsequently possessing the same degree of flow through the opening into the cylinder. When all the measuring material has flowed out, the cylinder is removed slowly without jerking, and by means of a light wooden disk with a handle the uneven surface of the material in the graduate is slowly leveled without exerting any pressure on it. This is done so that the right reading can be made. The reading is recorded, and the volume indicated in the graduated cylinder is taken to express the cranial capacity of the particular skull just measured for the series without shaking.

The method that was followed for the series with shaking is essentially similar to that just described as far as the filling of the skull is concerned. The fundamental difference is the application of mechanical force, shaking or pounding, to insure a uniform packing of the measuring material in the cranial vault, on the one hand, and in the graduated cylinder on the other.

To insure a good and uniform packing of the measuring material, we have resorted to shaking, dropping, and hammering the cranium and the measuring cylinder. These are followed and applied systematically with a certain definite number of times for each process and are done in as uniform a manner as it is possible to regulate and control. The cranium that is being measured is only halfway filled with the measuring material at first. It is then removed from the platform below the zinc vessel and shaken ten times from side to side. It is held above a table padded with rubber about 7 millimeters thick, and from a distance of approximately 2 centimeters it is dropped to the rubber pad five times. It is transferred to the platform again to receive more of the measuring material, until it is full. Thence it is removed again to the table and shaken vigorously from side to side for about twenty times. It is then hammered around with a wooden hammer that is padded with rubber at each end.

More of the material is now and then added to the contents by means of a large spoon until there is observed no more appreciable descent or settling of the measuring material. The hammering of the skull is applied at the two temporal regions, at the two malar bones, and over the occipital prominence, the hits beng delivered several times over each of these places. The skull is again dropped to the table five times from the same distance as before. There is usually observed, at this last procedure, no more sinking of the measuring material in the vault. If more space is created through this last maneuver, the skull is again hammered for about ten times and is dropped several times further until no more settling is seen; meanwhile, a little more of the material is added during the process. It will be observed that at this time only very little material need be added for the complete filling of the vault to the rim of the foramen magnum.

The material in the skull is then transferred to the empty zinc vessel for its retransfer through the funnel into the graduated cylinder for volumetric determination. The measuring material is transferred and packed into the cylinder by the same process as that followed in filling the cranium. The same maneuvers and degree of applying the shaking, the hammering, and the dropping are strictly followed. To avoid the breaking of the glass cylinder that has to undergo this treatment, we have padded its bottom with rubber taken from an old automobile inner tubing and we have placed two wide rubber bands around the two levels of the cylinder where hammering is applied. We have, besides, applied adhesive-plaster ribbon, an inch wide, around it at the upper end near its rim, to minimize the vibration of the cylinder produced by the hammering and dropping that caused the breakage of some of our cylinders in the early stage of our experiment. Just as in the filling of the skull, only one-half of the measuring material is admitted at first so that the packing is partially performed at first as was done in the skull. The final reading of the volume of the material in the cylinder is made after the last procedure of applying mechanical force is finished, when there is no more appreciable settling of the material. The figure given in the reading is taken as the cranial capacity of the particular skull used, for the series with shaking.

Three kinds of materials have been employed by us in measuring the cranial capacity of our series; namely, sand, seed, and shot. The sand used has been passed twice through a sieve having 60 meshes to the inch and openings of 0.0087 of an inch.

The bronze sieve used for this purpose was manufactured by The W. S. Tyler Company of Cleveland. The seed employed is white mustard seed which has been carefully selected and cleansed of its impurities. The shot is size 8 with 2.2 millimeters diameter. This shot was carefully examined as to its uniformity in size from time to time, and substitution was made at definite intervals to insure uniformity in diameter, avoiding thereby the reducing effect of the wear and tear on the shot from repeated use.

Other necessary precautions, as advised by Hrdlička, have been carefully observed in the use of the various measuring materials, to insure good and uniform results. In all the cases, the orbits were stuffed with absorbent cotton before the measuring was done; likewise, the inside of the cranium was examined in all instances for projections, abnormalities, or foreign bodies that might have affected the capacity determination of the brain case.

COMPARATIVE STANDING OF RESULTS OBTAINED FROM MEASUREMENTS WITH SHAKING AND WITHOUT SHAKING

One of the several objects we have in view in following the present study is to find out which kind of technic among those that we have used would show the nearest correct measurment of the cranial capacity; that is, which of the various results would contain the least error or variation. We thought of comparing primarily the various results of measurements obtained from the method without shaking and of comparing the result from this, in a parallel manner, to the results of a similar comparison of the various measurments obtained from the method with shaking. In our file cards of records of findings we have the following items of values of cranial capacity:

Method without shaking:

1, Volume in sand; 2, volume in seed; 3, volume in shot.

Method with shaking:

1, Volume in sand; 2, volume in seed; 3, volume in shot.

We compared the maximum, medium, and minimum records of cranial capacities obtained from the method without shaking in each case, irrespective of the kind of measuring material used, for a group of twenty cases selected at random, to the average cranial capacity of each case. The object in view is to discover the extent of variation between the maximum, medium, and minimum capacity recorded for each particular skull in relation to its mean capacity record. Under this procedure we obtained, in the group without shaking, the results in Table 3. This table

shows the existing variations of 47, 40, and 39 cubic centimeters from the mean by the maximum, medium, and minimum records, respectively. These variations range from 3.28 to 2.73 per cent from the mean average under this method.

Comparing in the same manner the maximum, medium, and minimum records of cranial capacity as obtained from the method with shaking in each case of the same twenty cases presented above, we derived Table 4. This demonstrates the existence of differences amounting to 25, 24, and 20 cubic centimeters, respectively, from the mean capacity value of the group in the method with shaking. These variations range from 1.92 to 1.53 per cent only.

TABLE 3.—*Degree of variation of measurements in the method without shaking.*

From the maximum.	From the medium.	From the minimum.	From the maximum.	From the medium.	From the minimum.
130	46	140	66	13	80
63	33	3	6	6	25
40	36	54	53	192	40
26	12	40	10	38	6
20	28	30	66	53	35
66	80	13	6	43	33
60	40	73	80	23	26
113	20	33	13	23	40
36	13	20	40	33	40
33	16	20	10	53	26
Average			[a] 47	40	[b] 39

[a] 3.28 per cent. [b] 2.73 per cent

TABLE 4.—*Degree of variation of measurements in the method with shaking.*

From the maximum.	From the medium.	From the minimum.	From the maximum.	From the medium.	From the minimum.
40	33	13	13	26	13
66	26	36	20	60	33
26	6	13	26	6	33
20	10	40	20	33	0
13	10	6	26	26	13
26	26	0	13	33	46
26	13	13	13	33	13
26	6	6	20	26	33
10	33	40	6	20	13
53	23	6	40	46	26
Average			[a] 25	24	[b] 20

[a] 1.92 per cent. [b] 1.53 per cent.

The findings shown in Tables 3 and 4 indicate that the measurements derived from the method with shaking differ from one another in a much lower degree than those obtained from the method without shaking. The variation existing from the minimum to the maximum in the former method ranges from 1.53 to 1.92 per cent, whereas in the latter it ranges from 2.73 to 3.28 per cent. In actual volumetric values these are 20 to 25 cubic centimeters divergence for the method with shaking and 39 to 47 cubic centimeters for that without shaking.

It can be safely concluded from this that the method with shaking offers in our hand less error or variation in the measurement. This conclusion seems to be fairly reasonable in view of the fact that, although we have followed a technic that will obviate as much as possible too much deviation by making the method mainly mechanical, yet in the method without shaking there seem to be more chances for variation than in the method with shaking. In the latter the mechanical influences are carried out to such an extent that the possibility of variation is very much narrowed down. The application of mechanical force has helped to minimize deviation due to the fact that the limit of possibility for either the vault or the cylinder to accommodate more measuring material is much lessened, unlike that in the method without shaking where there is less control on this possibility.

In this connection, it is of interest to mention the findings and opinions of some of the pioneer workers on craniometry regarding the extent of divergence they obtained in the capacity determination of the cranial vault. Welcker, in his account, claimed that he recorded a divergence in the determination of capacity of only 15 cubic centimeters when he himself made the observations on the dry-material method that he devised. Bartels, on the other hand, mentioned that he could not accept this narrow limit of divergence, that in his work he obtained a divergence of 40 cubic centimeters. Broca, with the use of the shot method, found that he could not get a difference or variation less than 40 cubic centimeters between successive determinations. In the use of the glass-perle method, Torok claimed that he could obtain an accuracy in the measurement of within 7 cubic centimeters divergence. Russel estimated his variation with the shot method as 16 cubic centimeters, and he claimed that in the direct water method this is reduced to 8 cubic centimeters.

With the special method devised by Hrdlička, wherein the mechanical procedure is much emphasized, and which is carefully followed in the present work, it has been claimed that with careful practice it should give a variation of generally less, and never more, than 15 cubic centimeters. We are frank to say that we are still a little way off from the divergence reported for Hrdlička's method. Even with the method with shaking that we have followed, the method that apparently gave in our hands the best result, we obtained a divergence of 20 to 25 cubic centimeters, some 5 to 10 cubic centimeters more than the divergence reported by Hrdlička. We probably have to admit that we lack the necessary experience in this kind of investigative work.

We have worked out the frequency distribution of our cases, both from the results of the method without shaking and those with shaking. There is found a shifting of the greatest frequency from the slightly higher values in the method without shaking to those with lower values in the method with shaking. The cranial capacity that we have obtained from the former method is thus comparatively larger than that derived from the latter method, as shown in Tables 5 and 6 of frequency distribution.

TABLE 5.—*Frequency distribution of cranial capacity in the method without shaking.*

Capacity.	Frequency.	Percentage.	Capacity.	Frequency.	Percentage.
cc.			*cc.*		
1,051-1,100	1	0.23	1,451-1,500	71	16.36
1,101-1,150	1	0.23	1,501-1,550	55	12.67
1,151-1,200	6	1.38	1,551-1,600	27	6.22
1,201-1,250	11	2.53	1,601-1,650	15	3.46
1,251-1,300	38	8.76	1,651-1,700	12	2.76
1,301-1,350	44	10.14	1,701-1,750	7	1.61
1,351-1,400	61	14.06	1,751-1,800	1	0.23
1,401-1,450	84	19.36			
			Total	434	100

It is seen from Table 5 (method without shaking) that the frequency distribution of the cranial capacity begins at 1,201 cubic centimeters, from where it follows a rise that is rather abrupt to between 1,401 and 1,450 cubic centimeters. Thence it starts to drop gradually to between 1,651 and 1,700 cubic centimeters. It is also demonstrated in the table that between the capacities of 1,401 and 1,500 cubic centimeters there is com-

prised 35.72 per cent of all the cases, and that between 1,351 and 1,550 cubic centimeters the number of cases included is 62.45 per cent. These points are better illustrated in the curve of frequency distribution in fig. 4.

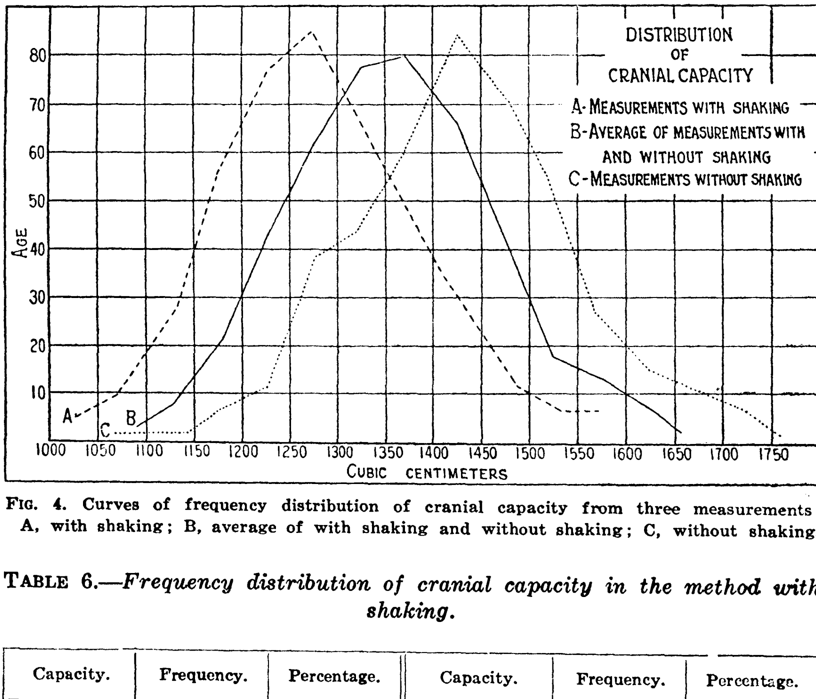

FIG. 4. Curves of frequency distribution of cranial capacity from three measurements: A, with shaking; B, average of with shaking and without shaking; C, without shaking.

TABLE 6.—*Frequency distribution of cranial capacity in the method with shaking.*

Capacity.	Frequency.	Percentage.	Capacity.	Frequency.	Percentage.
cc.			*cc.*		
1,001-1,050	5	1.15	1,351-1,400	47	10.80
1,051-1,100	10	2.30	1,401-1,450	34	7.81
1,101-1,150	27	6.21	1,451-1,500	12	2.76
1,151-1,200	55	12.65	1,501-1,550	7	1.61
1,201-1,250	76	17.47	1,551-1,600	7	1.61
1,251-1,300	85	19.54			
1,301-1,350	70	16.09	Total	435	100

Table 6 (method with shaking) demonstrates that the frequency distribution begins at 1,051 cubic centimeters from where the number of cases rapidly rises and reaches its maximum frequency at the capacity between 1,251 and 1,300 cubic centimeters. From this point it gradually descends to the capacity between 1,451 and 1,500 cubic centimeters. Between the capacities 1,201 and 1,300 cubic centimeters the number of cases comprised is 37.01 per cent, while between those of 1,151

and 1,350 cubic centimeters there are included 65.75 per cent of all cases. The course of the curve of frequency distribution for this method is shown in fig. 5.

The parallel condition of the curve of distribution found for the two methods is demonstrated in fig. 4 together with the curve of average values of the cranial capacity derived from both.

So as to study the comparative standing of the frequency distribution of the cranial capacity as obtained from the method with shaking as measured by the three different materials; namely, sand, seed, and shot, we have also traced the results of each

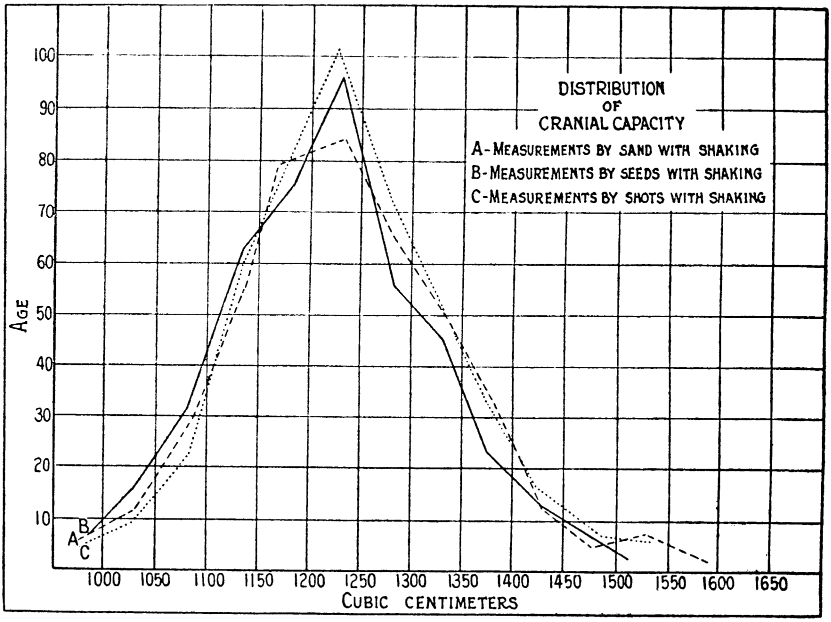

FIG. 5. Curves of frequency distribution of cranial capacity from the method with shaking: A, as measured by sand; B, as measured by seed; C, as measured by shot.

one and placed them together in fig. 5. Under this method with shaking, there is found with the sand material a frequency of 37.36 per cent between the capacities of 1,201 and 1,300 cubic centimeters, and 65.16 per cent between those of 1,151 and 1,350 cubic centimeters. With the seed for measuring material there is found a frequency distribution of 39.24 per cent for the capacities between 1,201 and 1,300 cubic centimeters, and 66.30 per cent between 1,151 and 1,350 cubic centimeters capacity. In the measurement with shot the frequency distribution is 35.77

per cent between 1,201 and 1,300 cubic centimeters and 66.04 per cent between 1,151 and 1,350 cubic centimeters capacity.

If the results are placed together side by side it will be seen that under the method with shaking there exist only small differences in the frequency distribution between the findings obtained from the three materials used in measuring. The differences observed are certainly much less than the difference met with in comparing the averaged findings derived from the method without shaking and that from the method with shaking. The above points are brought out clearer in studying the relative standing of the different maximum frequencies in Table 7.

TABLE 7.—*Maximum frequency distribution of cranial capacity in the various methods of measurement.*

Method.	Capacity.	Percentage frequency.
	cc.	
Without shaking (by three materials)	1,401-1,500	35.72
Do	1,351-1,550	62.45
With shaking (by three materials)	1,201-1,300	37.01
Do	1,151-1,350	65.75
With shaking:		
By sand	1,201-1,300	37.36
By seed	1,201-1,300	39.24
By shot	1,201-1,300	35.77
By sand	1,151-1,350	65.16
By seed	1,151-1,350	66.30
By shot	1,151-1,350	66.04

We have also employed the three materials for measuring the cranial capacity in the method without shaking, but we did not arrange the data gathered for frequency distribution. It is believed that the variation in the results from this method is considerably wider than that from the method with shaking as expressed in the previous findings for this method, so that it is not deemed important to present here their frequency distribution. The frequency distribution of the averaged data from the three measurements in the method without shaking, as given in the previous paragraphs, is believed sufficiently clear to show some important points on the capacity distribution of cases under this method.

MEAN VALUES OF CRANIAL CAPACITY

The mean values of cranial capacity met with in this series show a certain extent of variation in the different methods of measurements. This is particularly noticeable between the

method with shaking and that without shaking. The mean capacity obtained from the method without shaking is 1,423 ± 3.67 cubic centimeters, with a minimum of 1,060, and a maximum of 1,762. The unit difference in this method without shaking reaches an amount of 702 cubic centimeters. From the method with shaking there was obtained a mean of 1,301 ± 3.50 cubic centimeters, with a minimum of 1,016 and a maximum of 1,597, showing a unit difference of 561 cubic centimeters.

It is seen from the above figures that between the means from the two methods of measurement there is found a difference of 122 cubic centimeters. This difference amounts to about 8 per cent of the average value of the mean cranial capacity derived from both methods, which is 1,362 cubic centimeters.

It does not seem easy to decide from the mean values given above which one should be taken to represent the cranial capacity of the series of skulls now dealt with. Judging from the findings on the degree of divergence existing between the method with shaking and that without shaking, from the extent of deviations found between the results of measurements by the three materials (sand, seed, and shot) and from other indications that we have met during the process of working, we are very much inclined to consider the mean value derived from the method with shaking as the one probably nearest the actual capacity and that this can be preferably taken to represent the capacity of the present series of skulls. It is to be remembered that the series with shaking offered a divergence of only 1.53 to 1.92 per cent, while that without shaking gave a divergence of between 2.73 and 3.28 per cent. There is also to be considered, although not as important and as noticeable as the previous points, the relative standing of the probable error of each method. In the former the probable error is ± 3.67; in the latter, ± 3.50.

We have also studied in this connection the comparative standing of the means of the cranial capacity as measured by sand, seed, and shot. The object of this was to discover which of the three materials might have offered the most preferable result in deciding the mean cranial capacity for the present series. Under the method without shaking the means found are 1,468 cubic centimeters with sand, 1,429 cubic centimeters with seed, and 1,415 cubic centimeters with shot. It is seen that between the means with sand and with seed there is a difference of 39 cubic centimeters and between those with seed and with shot a difference of 14 cubic centimeters. The greatest difference

is that between sand and shot and is 53 cubic centimeters. The means obtained from the method with shaking show certain parallel results as those obtained from the method without shaking in reference to the use of three materials. Of these the one showing the greatest value under both methods is that recorded by sand. The means obtained from the method with shaking are 1,331 ± 3.81 as recorded by sand, 1,291 ± 3.38 as recorded by seed, and 1,282 ± 3.34 as recorded by shot. In the latter method the differences are not great, and the degree of probable error presented does not vary to so great an extent as to be of value in deciding which mean should be given preference. These findings do not seem to offer, as they are, definite choice on the mean cranial capacity. The probable errors presented revolve around very close values, and the differences are in fact negligible as far as choice of mean cranial capacity is concerned.

In the method without shaking and with the use of sand, seed, and shot we have found that the means are invariably greater than those obtained from the method with shaking. These are given in Table 8, compared with the means from the method with shaking. The purpose of the comparison is to see the relative difference between them with the idea of determining which material gave, in the process of measurement with shaking, the most-reduced capacity value.

TABLE 8.—*Mean values of cranial capacity as measured by three materials in the methods with and without shaking and their differences.*

Method.	Measured by sand.	Measured by seed.	Measured by shot.
	cc.	*cc.*	*cc.*
Without shaking	1,456	1,414	1,401
With shaking	1,331	1,282	1,291
Difference	125	132	110

This comparison indicates that there exists the least amount of difference in the measurements with shot between the methods with shaking and without shaking. This difference is 110 cubic centimeters; with sand it is 125 cubic centimeters; and with seed it is 132 cubic centimeters. This most likely means that with shot as the measuring material there occur less variations in the result, and that it afforded more-uniform results of measurement in the process of shaking. This is probably explained by the fact that as measuring material shot, properly calibrated and selected, possesses much more uniform size than

either seeds or sand and that in the forced filling of the cranial vault in the method with shaking each grain of shot could occupy a space of only its size giving thereby uniform size of void spaces, hence the more-uniform or less-variable volumetric result. Sand probably comes next to shot in point of uniformity in size of the individual grains. The sand used, as described before, is passed twice through a sieve of 60 meshes to the inch, and the grains are fairly uniform in size. Because of the fineness of the grains of sand, however, shaking of the material in the process of measurement with shaking will very likely give more variation than when shot is used, as the smallest grains of sand can still occupy the intervening void spaces between the larger grains. It is most likely due to these facts that the amount of difference shown between the various measurements with sand is greater than that with shot. In the case of seeds the variation is greater than that with sand or shot. This we explain is due to the lack of uniformity in the size of the grains of mustard seed used and that the void spaces are very irregular. Even with careful selection, the seeds are apt to be of various sizes and the result of volumetric measurement is in all probability more variable.

The tabulated summary of the mean cranial capacity derived from the various methods that have been followed is presented in Table 9. Included also are the probable errors, and the minimum and maximum records of cranial capacity with the unit differences existing between them. This also gives the mode and the median cranial capacity found for the various methods and materials.

TABLE 9.—*Summary of the mean, minimum, and maximum values of cranial capacity, probable errors, etc., of different measurements.*

Method.	Mean cranial capacity.	Probable error.	Minimum cranial capacity.	Maximum cranial capacity.	Unit difference.	Mode cranial capacity.	Median cranial capacity.
	cc.	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*
Without shaking (average of three materials)	1,423	3.67	1,060	1,762	702	1,426	1,433
With shaking (average of three materials)	1,301	3.50	1,016	1,597	581	1,276	1,277
With shaking (measured by sand)	1,331	3.81	1,005	1,640	635	1,282	1,280
With shaking (measured by seed)	1,282	3.34	1,010	1,560	550	1,281	1,270
With shaking (measured by shot)	1,291	3.38	1,010	1,600	590	1,277	1,280

In regard to the existence, in the actual findings, of greater capacity value derived from the method without shaking as compared with that obtained from the method with shaking, we desire to give in brief the following points that we judge must have been the contributory factors.

The differences observed are believed to be most probably due to the employment of the graduate cylinder for the volumetric determination of the measuring materials in both methods and to the dissimilarity between the form, the surface, and other qualities of the cranium and the graduate. The columnar form, the uniformity and glassy smoothness of the inside surface, and the greater height of the cylinder seem to be important factors that must have effected the differences in the results. The cranial vault on the other hand has irregular projections and a rough contour with the vertical dimension only one-third of that of the cylinder. It can be easily imagined that the material used in the measurement must have been lodged and packed inside the cranial vault quite differently from that in which it is found in the graduate cylinder. In the method without shaking the filling of the graduate by the material must have been unequal in the whole column of the material, even considering that the filling comes from the same standard funnel outlet. The density of the lower portion must have been more than that of the upper levels; that is, the density of any level in the column is inversely proportional to the height of the level. In the method without shaking the filling of the spherical vault of the cranium, with a height only one-third that of the cylinder, must have taken place more uniformly and the density throughout must have been more nearly uniform than in the cylinder. The same material, when transferred to the cylinder, must have assumed a little greater volume than it had in the cranium due to the gradual reduction in density from below upward in the cylinder. Under the method without shaking the void spaces present between the grains of measuring material in the cranium as well as in the cylinder, must have been greater in totality than the void spaces in the material under the method with shaking. The latter condition, associated with the former physical state of the measuring material, wherein there is unequal density in the cylinder, would seem to speak for the actual showing of greater volumetric capacity in the cylinder in the process of measurement without shaking. It can be reasonably expected, therefore, that the measuring material will assume in all cases a little larger volume in the cylinder under

the method without shaking than it will show under the method with shaking, even considering that the filling of the cranium by a given material is identical for both methods.

In the method with shaking, on the other hand, it is believed that the volume of the measuring material in the cranium when transferred to the cylinder and subjected to the same procedure of shaking and pounding, would not very likely assume increase in volume in the latter; on the contrary, it is believed it will suffer a slight reduction in volume. The measuring material cannot assume larger cubage in the cylinder under this method as the application of mechanical force will tend to equalize the volume in the cranium as well as in the cylinder, as the void spaces that are present between the grains of measuring material will be reduced to their lowest limit and effect thereby a more uniform packing inside them, notwithstanding the differences in size and in form of the two. The assumption that the volume of the material in the cylinder might have suffered further slight reduction in volume is thought due to the fact that the inside of the graduate has a much more uniform contour and a smoother surface than the cranium and that the material contained in the former might assume such a compactness as to reduce both the number and the size of the void spaces in the cylinder to a further extent than in the cranium, causing thereby a little lower volumetric reading under the method with shaking.

Under the above-described conditions of measurement it is believed that, taking everything into consideration, including other points and findings met with in the course of this work, the expression of cranial capacity that will approach nearest the correct or actual capacity of the crania is the average value calculated from the results derived from the use of the three different measuring materials under the method with shaking. Under this consideration the cranial capacity of this series will be 1,301 cubic centimeters, with the standard deviation of 108.58 and probable error of $\pm$ 3.50.

We are presenting (Plates 2 and 3) the pictures of crania for both the male and the female groups of our series that possess the maximum and minimum cranial contents as met with in our process of measurement. Figure 3 represents the male cases, one with the highest cranial capacity of 1,655 cubic centimeters (case 544); and the other possessing a minimum capacity of 1,083 cubic centimeters (case 350). These cubages given here are based on the mean values of records from all

the three materials used in measurements under the method with shaking. Figure 4 represents two female crania possessing a maximum capacity of 1,480 cubic centimeters (case 134), and a minimum cranial contents of 897 cubic centimeters (case 480). The pictures show the frontal, lateral, and superior views. The other data of these four cases of crania together with various cranial measurements derived from them are given in Table 10.

TABLE 10.—*Cases with maximum and minimum cranial capacities and their cranial measurements.*

No. of cranium.	Sex.	Age.	Cranial capacity.	Maximum antero-posterior diameter.	Maximum transverse diameter.	Basio bregmatic height.	Auriculo bregmatic height.	Sagital arc.	Transverse arc.	Horizontal circumference.
		Yrs.	*cc.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
544	M	31	1,655	178	153	145	126	390	345	520
350	M	48	1,083	159	129	132	113	343	299	460
134	F	45	1,480	183	138	132	114	367	312	511
480	F	46	987	163	128	127	106	327	282	469

FEMALE CRANIA

The number of female crania in the present series is small, and we feel skeptical in reporting the measurements obtained from them. The twenty-two cases are given here for what they are worth, together with their cranial capacities as obtained from the average of the three materials employed under the method with shaking.

TABLE 11.—*Records of female crania.*

Serial No.	Case No.	Age.	Cranial capacity with shaking.	Serial No.	Case No.	Age.	Cranial capacity with shaking.
		Yrs.	*cc.*			*Yrs.*	*cc.*
1	480	46	987	12	91	51	1,215
2	629	40	1,015	13	342	95	1,225
3	355	76	1,032	14	466	20	1,239
4	340	100	1,048	15	215	34	1,240
5	165	70	1,075	16	431	89	1,248
6	359	57	1,097	17	531	65	1,255
7	503	15	1,107	18	242	33	1,274
8	291	43	1,123	19	129	80	1,283
9	90	80	1,205	20	248	25	1,326
10	619	80	1,205	21	401	48	1,341
11	441	35	1,209	22	134	35	1,480

The minimum capacity found for the female skulls is 987 cubic centimeters, and the maximum capacity recorded for them

is 1,480 cubic centimeters, showing a unit difference of 493 cubic centimeters. The mean capacity obtained is 1,192 cubic centimeters, with a standard deviation of 118, a probable error of ±16.86, and a coefficient of variation of 9.88.

Comparing the above values with those obtained from the male group of our series, it is observed that the male cranial capacity is superior by 96 cubic centimeters between their minimum records, by 209 cubic centimeters between their mean values, and by 175 cubic centimeters between their maximum records. These amount to 8.86, 16, and 10.57 per cent, respectively. Table 12 shows these differences.

TABLE 12.—*Comparative table of male and female cranial capacity.*

	Cranial capacity.			Standard deviation.	Probable error.
	Minimum.	Mean.	Maximum.		
	cc.	*cc.*	*cc.*	*cc.*	*cc.*
Male	1,083	1,301	1,655	108.58	3.50
Female	987	1,192	1,480	118.00	16.86
Difference	96	209	175		

It may be interesting in this connection to see the comparative standing of the male and the female physical measurements and their correlation with their cranial capacity values. We can only present here the measurements found by Nañagas for the adult Filipino students of the University of the Philippines, as no comprehensive data from a more-extensive portion of the population have been reported. They are presented only for a cursory comparison and need not be taken with definiteness. The male stature is 163 centimeters with a body weight of 50.6 kilograms. The female measurements are, respectively, 152 centimeters and 43.2 kilograms. The difference in stature between the two sexes amounts to 6.7 per cent, and the difference in body weight is 14.8 per cent. It is seen that there is considerable discrepancy between the records of cranial cubage (16 per cent) and that of stature (6.7 per cent). However, the difference in cranial capacity between the two sexes approaches their difference in body weight, the latter amounting to 14.8 per cent. The presence of the former discrepancy we cannot very well explain; it may be due to the limited number of female cases represented. The difference between the cranial capacity on the one hand and the body weight on the other is very slight.

COMPARATIVE STUDY ON THE CRANIAL CAPACITY OF VARIOUS CASES

It does not appear fair to follow up a comparison of the various results and findings as obtained from different sources and authors with those of our data when the methods employed in different types of cranial measurements do not exactly coincide and where the effects of personal equation are as variable as are the methods used. Nevertheless, it is interesting in some way to get an idea of the gross comparative standing of the different races on this question of cranial cubage, even on a provisional and introductory manner only, for the time being, until more-definite and comprehensive data are gathered which will be more scientifically comparable.

In presenting our comparison in this paper it is desired to mention frankly that we are doing it with the full knowledge that our comparison will be incomplete in some ways and it will probably be not as nearly ideal as we would like to have it. In a comparison of data on an important measurement like the cranial capacity of man, there should invariably be presented also the records of their stature, body weight, build, constitution, and several other physical records that have some direct relationship with the cranial capacity. These measurements enumerated cannot be presented together with the fundamental measurement taken up in this paper as it is not within our reach, at the present time, to gather and closely scrutinize comprehensive data on physical measurements of other races.

We have gathered but limited data on cranial cubage of other races from the literature locally available. These data were reported by various authors from different numbers of cases; some with the technic of measurement described, others with their methods not given.

The comparisons are given mainly in tabulated form, and only little attempt is made in discussing the degree of comparative peculiarities of our cranial capacity with those of other races as reported by foreign authors. Similarly, we do not feel justified in drawing any definite conclusion in this paper as we regard this as a mere opening study on the craniometry and anthropometry of the Malays as represented by the Filipinos in this region. In considering a fundamental measurement like the cranial capacity we realize that there should be proper care and patience, and due time given for additional work before drawing conclusions; and that in this particular point of com-

parison we feel that we are only justified in the present instance to consider our findings as temporary.

In Table 12 are represented some fairly complete records of cranial capacities of the American, German, Negro, Aino Japanese, Nagada, and our Filipino group. The foreign data were obtained from the work of Todd on the Americans (white and negro) and as quoted by him for the German, Aino, and Nagada from the work of Pearson; and also for the African Negroes (Batetela and Gaboon) as quoted by him from the studies of Crewdson Benington.

The record of measurement that we are presenting in this tabulation is that derived from the type of measurement obtained with shaking, as this is the capacity, according to our judgment, that probably approaches nearest to the correct or actual volumetric contents of the series of crania here dealt with, as already pointed out and discussed elsewhere in this paper.

TABLE 13.—*Comparative table of cranial capacity of various races.*

Authors.	Race or stock.	Sex.	Number of cases.	Mean cranial capacity.	Standard deviation.	Probable error.	Coefficient of variation.
				cc.	*cc.*	*cc.*	
T. W. Todd	American (white)	Male	167	1,391	117.58	4.34	8.45
Do	do	Female	31	1,231	126.32	10.79	10.25
Do	American (negro)	Male	87	1,350	128.16	6.54	9.50
Do	do	Female	17	1,220	123.96	14.16	10.15
Lea and Pearson	German	Male	100	1,503	116.89		7.77
Do	do	Female	99	1,337	108.73		8.13
Do	Japanese (Aino)	Male	76	1,461	100.60		6.88
Do	do	Female	52	1,307	89.75		6.86
Do	Nagada	Male	69	1,386	104.36		
Do	do	Female	98	1,279	94.03		
R. C. Benington	African Negro (Batetela).	Male	47	1,343	126.57	8.81	9.42
Do	do	Female	21	1,205	107.68	11.21	8.93
Do	African Negro (Gaboon).	Male	49	1,380	107.69	7.34	7.80
Do	African Negro	Female	43	1,231	126.63	9.20	10.28
J. C. Nañagas	Malay (Filipino)	Male	436	1,301	108.58	3.50	8.33
Do	do	Female	22	1,192	118.00	16.86	9.88

In order to understand better the relative standing of the cranial capacities compared in the above tabulation, it is necessary to quote verbatim from Todd to show certain view points in his comparison. It will help to clarify to some extent the comparative interpretation of findings on the present group.

The German series used by Lee and Pearson are Ranke's Alt-Baieriche collection which may be taken as a series fairly representing the mediaeval

Bavarian population of the country-side. It is a rather homogeneous series. Our own Whites are as heterogeneous as could be imagined for they consist of the human flotsam which has drifted west, some from the British Isles but vastly more from the countries along the North Sea and the Baltic from the Rhine to Riga and the hinterland back to the Danube. I am not absolutely sure that our female population (and by population I mean the material of the laboratory upon which alone our views are built) is the same as the male. There are some features about the females which seem to indicate an older American stock, but the discussion of this problem must be reserved for a future occasion. The consequences of the difference in homogeneity between our material and Ranke's Bavarians will become increasingly evident but the rather striking difference in mean capacity is certainly not due to degree of racial purity. Lee and Pearson give a mean capacity for the male of 1,504 cc.; the mean capacity of our male White material is only 1,391 cc. We have already noted that it is quite proper to compare these two series, having regard to the methods of determination of capacity. The difference in capacity cannot be attributed to difference in technique in this case although it is true that technique has usually been to blame for at least part of the discrepancy between the conclusions of various observers. In the later parts of this work it will become increasingly apparent that we have here a real difference and the origin and production of the difference in capacity will become evident. Between these two series the difference of the means is 113 cc. and the probable error of this difference is 15 cc. Between the corresponding female series the difference of the means is 105 cc. and the probable error 25 cc. There is no doubt therefore about the reality of a fundamental difference between the two groups of crania. Now it is also rather significant that the male Bavarians show a capacity 8.1% greater than our male Whites, and the female Bavarians show a capacity greater by 8.5% than the mean of our female White. Our material is certainly not representative of the average population of the city. It is a shiftless population recruited from the water front, the criminal districts and the underworld. Interpreted in this manner and compared with the average country-side population of old Bavaria it gives a suggestive indication of the effect of the selection of crime, drunkenness, and poverty. We are also impressed with the pronounced influence of selection of one kind or another upon the mean capacity as established by different workers. The startling divergences in mean capacity apparently referring to samples of the same race, which so thoroughly aroused the attention of Welcker and other investigators and have been partly responsible for discouraging work on cranial capacity, are undoubtedly due in part to differences in the sample. This emphasizes the prime importance of sparing no pains to obtain and publish all data respecting the origin of the sample in question and the necessity of studying the probable influences at work in its selection.

Turning to the Negro figures we find an entirely different kind of selection at work. Our material is much more truly representative of the general negro population in America than is the case with our White material. Here we are dealing with a problem, not of crime and moral obliquity, but of misfortune and hereditary disadvantages. In the later communications we shall find ample confirmation for this thesis. If upon general principles which cannot be fully discussed at this juncture, the

point be conceded, we are enabled further to consider the relation of our Negro series to the various African groups hitherto studied. I have expended a good deal of effort with quite unsatisfactory results upon the problem of the precise African origin of our Negro population. Various scholars who have devoted thought to the origin of the American Negro have been able to produce merely scanty and comparatively worthless evidence. Hawkins' journals give little help and I am not at all clear as to from how far along the coast of West Africa and how far into the interior our Negroes came. The more I think of this problem, however, the less do I come to value the result of the investigation. There is no doubt that a great mixture of native types and races had taken place in the very areas from which of necessity our Negroes must have come. In the beginning the American Negro undoubtedly belonged to quite as heterogeneous a group as the Whites who have voluntarily followed him to these shores during the past century. The physical characters of our Negroes show plainly that they came from West Africa and not from North Africa or from far south of the equator. A much more significant question, and one more promising of settlement than original African areas, is the condition of the Negroes after arrival in the West Indies. One would like to ascertain how greatly they mingled their blood with that of other races especially of the Whites, and again, what effect contact with the White man or, if one please so to term it, civilization, has had upon their physical characteristics. On another occasion I hope to take up these points seriatim but this is too early in the investigation to deal with the problem usefully.

* * * Instead of a marked difference between the means such as we have found in the case of the Whites, our Negro mean falls between those of the two Negro series now being compared. The difference between the means of our material and the Batetela males is only 6 cc. and the error of this difference 23 cc. For the Gaboon and our males the difference in mean capacity is 51 cc. but the probable error of the difference is 21 cc. The corresponding differences in the means of the females are 15 cc. for the Batetela with an error of 38 cc., and the difference of 10 cc. for the Gaboon with an error of 36 cc. In no case therefore is there any significant difference. Not one of the series is really large and the female groups are merely included to complete the suggestiveness of the survey. It is apparent that all these groups of crania come essentially from the same people, that our series is fairly representative of the population at large, and that contact with the White man, and even the formation of hybrid material, over three hundred years has not in the slightest obscured the plainly Negro characters. The extraordinary similarity between our Negro males and the Batetela males in mean capacity, standard deviation and coefficient of variability cannot pass unnoticed. We shall see later that the American Negro has longer and rather higher head than the Batetela and in these respects approaches the Gaboon group. Therefore the close similarity with the Batetela in the table must not be over stressed; it is interesting but not necessarily significant.

One may be surprised to observe the degree of relative standing of the cranial capacity value of the Filipino group here presented as compared with those of the other races.

Under a more-careful consideration, however, one will easily understand that the surprise created at first sight is mitigated by the parallel study of their other fundamental physical characteristics. We have in mind those of stature, body weight, build, and the relative size of the heads. These basic physical differences between races must necessarily be considered, as we have already emphasized in the first part of this paper, if a proper manner and a fair type of comparison is to be followed.

It can be seen that our cranial capacity, compared with that of the American white, as reported by Todd, shows a lower difference of 90 cubic centimeters, amounting to 6.91 per cent. This difference is only expected, as there actually exist considerable differences between the body sizes and build of the two people. In stature alone the American white surpasses the Filipino, the former being under the classification of the "high stature" whereas the latter is known to belong to the "stature below the average." According to our available literature, their stature is given around 175 centimeters, their body weight around 68 kilograms, and their build about 22. Those of the Filipino, on the other hand, as found by Nañagas, are respectively around 163 centimeters, 50 kilograms, and 19. The Filipinos, or the Malays, being a smaller type of people, would have a proportionately smaller head measurement.

It is noticed that the difference in stature of the two races falls around 7 per cent, which closely parallels, in degree, their difference in cranial capacity. The difference in body weight, however, is considerably more than that in stature, this reaching around 32 per cent. Body weight is of course a fairly variable body measurement, much more so than stature, and it does not serve as good a point of correlation as the latter in the study of physical developmental conditions of different races. The great difference reported for the body weight is significant of the lower condition of body nutrition among the Filipinos, which has been emphasized repeatedly by the writer in some of his publications. From the greater discrepancy between the body weights on the one hand, and the smaller relative difference in their cranial cubage as herein found between the two, it may be inferred that the cranial-capacity record of the Filipinos is comparatively good and proportionately high; their body weight being very much lower. This signifies also that the Filipinos have poor body nutrition and development and that this condition does not seem to affect their cranial capacity, thus showing once more the rather invariable condition of the

cranial contents, unaffected by the irregular and frequently changing condition of the rest of the body as expressed in body weight.

It should be mentioned in this connection that the present Filipino group under consideration is not representative of the mass of our population. It constitutes mainly the very poor ignorant class of the inhabitants (cases unclaimed from the city morgue), who are prone, through indulgence, to do ruthless and criminal acts for their means of livelihood; or are apprehended by the police authorities for their bad practices through superstitions and ignorance. A great majority of these cases came from the Government penitentiary, as mentioned in the early part of the paper.

Ethnologically, this group is quite homogeneous, all the cases belonging to the Malay stock of our population, although some of them carried an admixture of Mongolian blood. It is to be noted that throughout the whole of Indonesia and Malaysia there exists a considerable admixture of Mongolian blood, derived principally from the Chinese infiltration of these regions, and coming mostly from South China. This was true for several centuries in the past and is going on, to a certain extent, at the present time. This admixture is the commonest type that is observed now among the people inhabiting the Philippines, this is seconded by the Iberian admixture effected by the occupation of the Islands by the Spaniards for a period of more than three centuries.

In regard to the lesser value of cranial capacity demonstrated by our group compared with those of the Negroes, both of America and Africa, it is believed that the physical differences existing between the two kinds of races explain the presence of such collateral difference in cranial cubage. Physically, the Negroes are a much taller and larger race than the Malays. The African Negroes, from which the American Negroes were originally extracted, range in stature from around 170 to frequently more than 180 centimeters; whereas the Filipinos reach a stature of only around 165 centimeters. Such an existing large difference in height will certainly influence the relative values of their cranial cubage. This difference amounts to around 6.8 per cent. In cranial capacity on the other hand the difference amounts to around 3 per cent only between our record and those of either the American or the Batetela Negroes. Our series shows a cranial capacity of 6 per cent less than the Gaboon Negroes.

The above figures show again, according to our judgment, that our cranial capacity does not appear too small in comparison with that of other races when other physical differences are taken into account.

One of the interesting comparisons shown in Table 12 is that of the German Bavarian and that of our group. Both of these series, Bavarian and Malay, are fairly homogeneous in type as far as their racial compositions are concerned. It is significant that there exists a strongly marked difference in cranial capacity between the two. Their mean cranial capacities, 1,503 cubic centimeters for the German and 1,301 cubic centimeters for the Filipino, show a difference reaching 200 cubic centimeters, and amounting to 15.5 per cent more for the Bavarian. This European series, as described by Todd, was derived from a Bavarian population of the country-side. These people must have possessed a medium stature, although this was not described by Lee and Pearson. They must have belonged also to that rather common German type of man possessing a fairly large brachicephalic head frequently met with throughout Prussia. It is only to be expected that this brachicephalic type, with a high cranial index, about 83, must possess a much larger cranial cubage than those of our series. The Malays, as reported by various authors, possess a mean cranial index of around 75.

The difference in stature, although not as prominent as in those of the other races compared, must have something to do with the greater cranial capacity record of the Bavarian over that of our present series. Another point that may be added is the relative degree of cultural level of the two series. The cases composing ours, as mentioned already in the preceeding paragraphs, happened to come from the low, ignorant, and criminal class of our population, which in cultural and educational standing must be far below that of the country-side inhabitants of Bavaria. The German series is a representative homogeneous group, whereas ours, although likewise of homogeneous Malayan blood, is not representative of the great, literate mass of our present-day population.

There is likewise noticed a considerable difference in cranial capacity between the Ainu, the aborigines of Japan, and our series. This amounts to nearly as much as that of the Bavarian record. The mean cranial capacity of the Ainu is 1,461 cubic centimeters, in contrast to the present Malay series of 1,301 cubic centimeters. This difference is 160 cubic centi-

meters, or 12.2 per cent, more than that of our group. It is rather suprising that the Ainu possesses a much higher cranial cubage than the Malay. The Ainus of course are known to possess good physique, having better-developed and heavier-set bodies than the Malays. In stature, however, the two races are almost the same, the reported height of the former is 158 centimeters, whereas the Filipinos possess even the slightly higher stature of 163 centimeters. In cephalic index also they are closely similar; the Ainus have a cephalic index of around 76 as reported by foreign observers.

It has been alleged and confirmed by many ethnologists that although the much-discussed Hairy Ainus are indigent inhabitants of Japan, yet there are enough reasons to consider them as survivors of the remote Asiatic branch of the Caucasian race, and that they are not really Mongolian. What bearing this particular claim has on the higher record of their cranial capacity, as mentioned here, the writer is not in a position to discuss.

In following up the above type of comparison, which is rather superficial we admit, the writer feels somewhat skeptical in employing records from different observers that were derived from measurements taken with varied technics. This point we have already mentioned in the early part of this topic. It is observed that under certain conditions the difference in capacity seems to be attributable to the discrepancy in methods and that the existence of some contradictions between results and conclusions are mainly due to this and other associated factors. We are stating this simply to mention once more that such comparisons, like this one we followed, are only tentative and that whatever conclusions or assertions are made to explain a finding should be taken only provisionally. Of course an ideal way to have a satisfactory comparative study of cranial capacity, or of any other fundamental body measurement, of the different races of people is to have a single well-equipped and properly organized institution for each line of work which will uniformly take care of measuring, compiling, and reporting the data and results gathered from different regions of the world. This kind of institution should be international in scope, and measurements should be undertaken in the field directly with instruments carefully tested and with methods painstakingly studied. Under this seemingly idealistic, but perfectly workable idea we can expect, with greater confidence, many significant results and conclusions on the comparative physical standing of the different races of mankind.

The comparative standing of the female group of our cases with those of the foreign records of cranial capacity can be seen in Table 14 together with the comparison of the male data. We did not discuss the relative standing of the female groups as they more or less follow, in a lower parallel degree, the differences existing between the male series, and thus a similar line of reasoning can be applied in their comparison.

TABLE 14.—*Actual and percentage differences between the cranial capacity of other races and that of the Filipinos.*

Race or stock.	Males.		Females.	
	cc.	*P. ct.*	*cc.*	*P. ct*
American White	90	6.91	40	3.35
American Negro	49	3.76	28	2.43
German Bavarian	202	15.52	145	12.25
Japanese Ainu	160	12.29	115	9.64
Nagada	85	6.53	87	7.34
African Negro (Batetela)	42	3.22	13	0.99
African Negro (Gaboon)	79	6.07	39	2.99

SUMMARY

The total number of crania available for this study is four hundred fifty-eight. Four hundred thirty-six are males and only twenty-two are females.

The geographic distribution of these cases coincides, in frequency, with the degree of the actual thickness of population of the different principal regions of the Archipelago. One unfortunate incidence in this series is the fact that a great majority of them were inmates of the Government penitentiary.

Of the two principal methods of capacity measurement—with shaking and without shaking—the former has given us better results. The results from this type of measurement can be taken, in our opinion, to represent the nearest to the actual capacity of the crania under study.

Of the three materials used for measuring—sand, seed, and shot—the last, when properly calibrated, gives the least variable results. Under the method with shaking, however, all the three materials used showed but slight variations so that the average of the results of the three should preferably be taken to represent the cranial capacity value of the cases.

The maximum cranial capacity found for the male group is 1,655 cubic centimeters, and the minimum is 1,083. For the female group, the maximum is 1,480 cubic centimeters and the minimum 987.

The mean cranial capacity for the male group is 1,301 cubic centimeters, with a standard deviation of 10.858; for the female group, 1,192 cubic centimeters, with a standard deviation of 118.

Comparison is made of the cranial capacity obtained from the present series with those of other races. It was found that in the Filipino it is relatively smaller, falling more or less in direct proportion to the difference in stature and general physique existing among the various races and nationalities.

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ILLUSTRATIONS

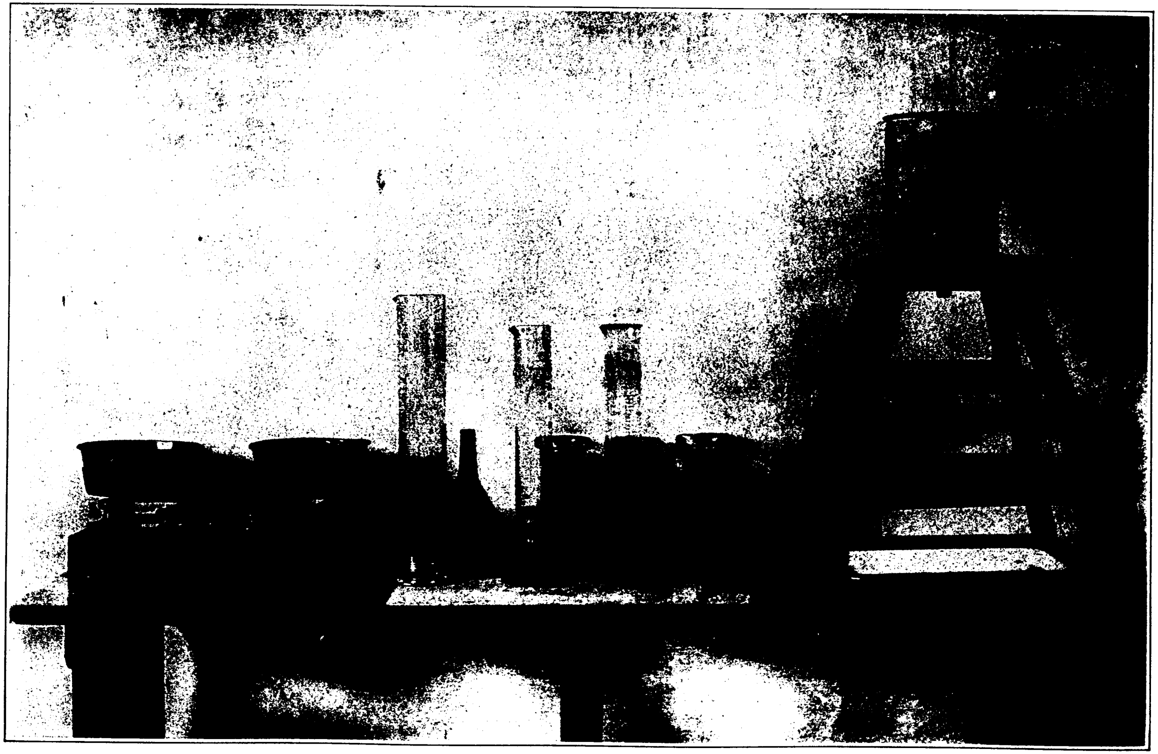

PLATE 1.

PLATE 2.

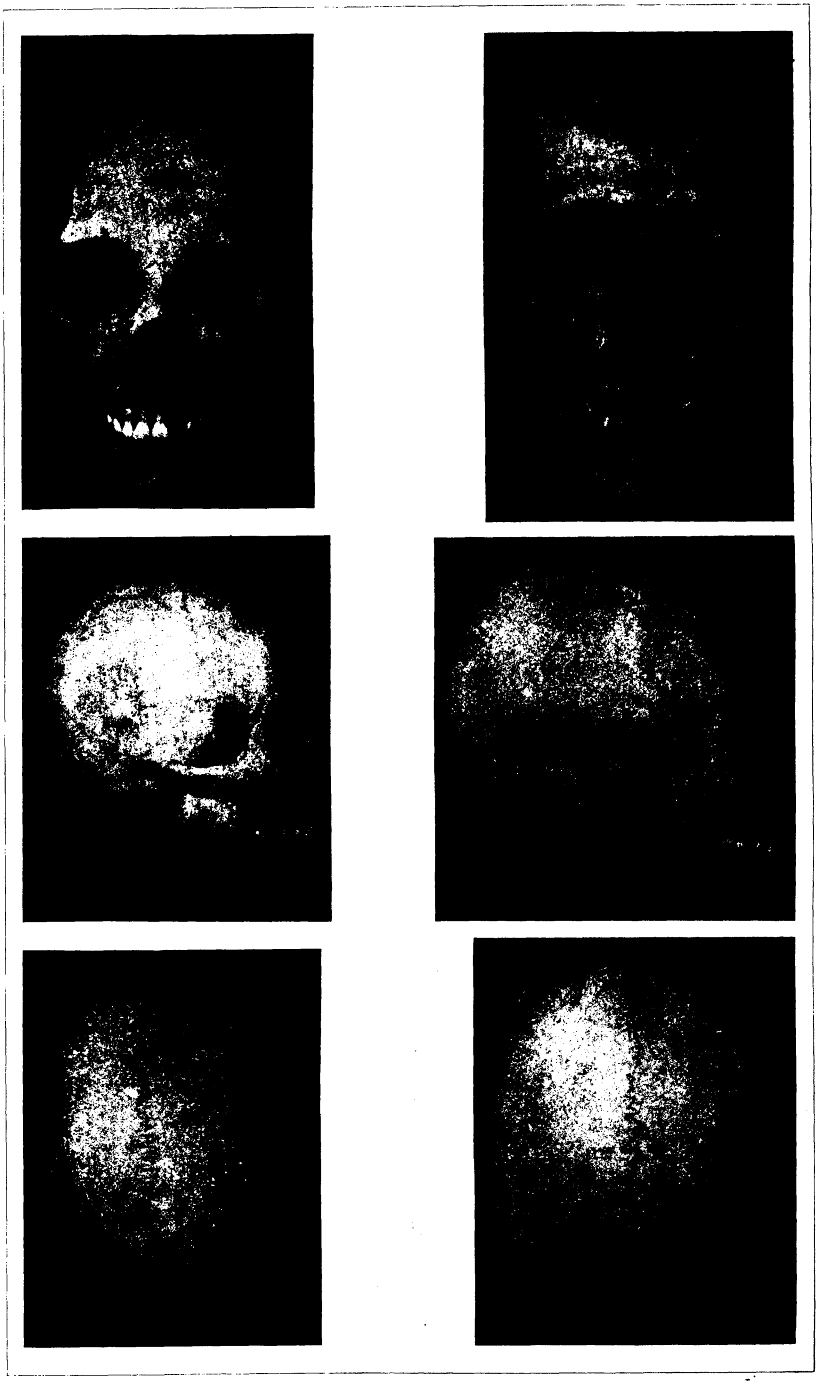

PLATE 3.

AN AMERICAN CYPRINODONT IN PHILIPPINE SALT PONDS

By Albert W. Herre
Of Stanford University, California

THREE PLATES

Mollienisia latipinna Le Sueur is a small cyprinodont fish native to the coastal region of the southern United States. It occurs from Virginia to northern Mexico and is very abundant in lowland streams and swamps. It often enters salt-water bays and inlets and is common in the shallow water about ports of the southern Atlantic and Gulf States. Le Sueur's type specimen came from New Orleans.

It was, therefore, a matter of great interest to discover that this little fish, belonging to a family confined to America, occurs in vast numbers in some of the salt-water fishponds and salt ponds around Manila Bay.

In the spring of 1927, while I was engaged in an exhaustive survey of the bañgos ponds along the shore of Manila Bay, a small cyprinodont fish was discovered in certain localities. The fish was very well known to the caretakers of the ponds and was called "bubuntis" by them. Bubuntis is a Tagalog word meaning pregnant and is applied to this fish because of its large belly.

At first I supposed that bubuntis was new to science, but comparison with specimens of *Mollienisia latipinna* from Savannah, Georgia, showed their identity. Bubuntis is, therefore, a fish accidentally naturalized in a new locality halfway round the world from its natural habitat.

The most noticeable thing about the life of bubuntis in the Philippines is its remarkable toleration for salt. In the salt works it is rare in ponds filled with water fresh from the bay, with a salinity as low as 3.1 to 3.2 per cent, but is abundant in those with a salinity of 3.5 per cent. It continues to be abundant in salt ponds until the salinity increases to 6.3 per cent. When evaporation has brought the salinity up to 6.7 per cent bubuntis becomes very abundant, and continues to be so until the water of the ponds attains a salinity of 8.7 per cent.

This, however, seems to be near its limit of tolerance, for in ponds with a salinity of 9.4 per cent it has entirely disappeared. All other kinds of fish occurring in the salt ponds disappeared while bubuntis were still very numerous and lively.

In the Philippines bubuntis is thus far known only from the salt-water ponds maintained for the culture of bañgos (*Chanos chanos* Forskål), the salt-water creeks supplying them with fresh water from Manila Bay, and the ponds of salt works, situated only along the shore of Manila Bay, Luzon.

In 1905, Mr. Alvin Seale was commissioned by the Hawaiian Government to go to the United States and obtain fish feeding upon mosquito larvæ, these fish to be used in the antimalarial campaign then in progress in the Hawaiian Islands. At Seabrook, Texas, Mr. Seale obtained a quantity of *Gambusia affinis* and some specimens of *Mollienisia latipinna*. These he succeeded in transporting to Honolulu, where they were placed in ponds, streams, and irrigation ditches. Here they found conditions just as congenial as in their native habitat. *Gambusia* proved to be wonderfully efficacious in devouring mosquito larvæ, but *Mollienisia* was of no practical utility for this purpose.

In 1913 while returning to Manila from the United States, Mr. Seale took twenty-four specimens of *Gambusia affinis* from Honolulu to the Philippines. Here they reproduced as rapidly and were just as valuable in destroying mosquito larvæ as in the Hawaiian Islands.

In 1914, the Director of the Bureau of Science sent to Honolulu for a shipment of *Gambusia*. A barrel of small fish was sent, but when the shipment arrived the fishes were found to be nearly all *Mollienisia*. These fish were placed in aquarium tanks, and Mr. Seale gave orders that they were not to be distributed with mosquito fish.

Apparently this order was disregarded after Mr. Seale left the Philippines in 1916. As a result *Mollienisia*, or bubuntis, now occurs in such abundance in some of the fishponds as to be a serious detriment to their success. This is especially true in the nursery ponds, since bubuntis there devour the food that bañgos fry feed upon, thus cutting down their food supply.

Bubuntis feed upon the algal complex that covers the bottom of nursery ponds. This layer, known as "cream of the mud" and called "lab-lab" by the Tagalogs, is composed of a mat of blue-green algæ with which are mingled diatoms, desmids, some fine filamentous green algæ, and quantities of protozoans and other microscopic animals. Bubuntis also eat the common green

filamentous algæ, the "frog spittle," or "lumut," of the fishponds, to a limited extent. The position of the mouth and the character of the teeth indicate that very small insects and insect larvæ must form a portion of their diet. I have examined microscopically the digestive tracts of many specimens and found them to contain large quantities of mud, mineral crystals, bits of filamentous algæ, unicellular algæ, and minute crustaceans or parts of them.

Bubuntis is one of the very few fishes not eaten by Filipinos, the reason being that the flesh is bitter.

POECILIDÆ

The statement made by most authors that in the Poecilidæ the dorsal fin begins in the caudal half of the body should be modified. In *Mollienisia* the dorsal fin begins in the middle or more often in the anterior half of the body, usually nearer the tip of the snout than the base of the caudal.

Genus MOLLIENISIA Le Sueur

Mollienisia LE SUEUR, Journ. Acad. Nat. Sci. Philadelphia 2 (1821) 3, pl. 3.

This genus is composed of small, viviparous, laterally compressed fishes, the females deeper bodied than the males; the depressed head flattened above, with a wide, blunt snout and very short mandible, its bones not united, the dentary movable; the vertical mouth protractile, the chin projecting; an outer row of very small, slender, pointed, curved teeth in each jaw; within and separated from the outer row by an interspace a double row of smaller teeth; upper and lower pharyngeals covered with minute, curved, pointed teeth; dorsal elevated in the male, of twelve or more rays, anal behind the dorsal and modified in the male to serve as an intromittent organ; ventral of six rays; caudal bluntly rounded, caudal peduncle deep; pectorals inserted on lower half of body; scales large, cycloid, covering the entire body except lips and preorbital; no lateral line; intestine much coiled, five or six times the total length, the anus posterior; gill opening broad, gill membranes free from isthmus; no pseudobranchiæ; branchiostegals 5 or 6.

Small fishes of fresh, brackish, and salt water, from Virginia to Central America.

MOLLIENISIA LATIPINNA Le Sueur.

Mollienisia latipinna LE SUEUR, Journ. Acad. Nat. Sci. Phila. 2 (1821) 3, pl. 3; GUNTHER, Cat. Fishes Brit. Mus. 6 (1866) 348; JORDAN

and EVERMANN, Fishes N. and M. Am. 1 (1896) 699; GARMAN, Mem. Mus. Comp. Zoöl. 19 (1895) 50, pl. 5, fig. 1; pl. 8, fig. 12; pl. 12.

Poecilia multilineata LE SUEUR, Journ. Acad. Nat. Sci. Phila. 2 (1821) 4, pl. 1.

Poecilia lineolata GIRARD, U. S. Mexican Boundary Surv., Ichthyology (1858) 70, pl. 35, figs. 9–11.

Limia poeciloides GIRARD, U. S. Mexican Boundary Surv., Ichthyology (1858) 70, pl. 38, figs. 8–14.

Limia matamorensis GIRARD, Proc. Acad. Sci. Phila. (1859) 116.

Tagalog name, bubuntis.

Dorsal II–10, or 11; anal III–6 in female; anal in male II + 4 + 3, the middle rays much enlarged and modified to serve as an intromittent organ; scales 25 in longitudinal series, 9 or 10 in transverse series; predorsal scales 13 in female, 10 or 11 in male; branchiostegals 6 (Garman, and Jordan and Evermann give 5).

Head and body strongly compressed in male, depth 3 to 3.5 in length, not including caudal fin; the female has a large and often protuberant belly and the anterior half of the body somewhat thicker than in the male, depth 2.5 to 3 in length in female; caudal fin not included; dorsal outline arched, descending from dorsal to tip of snout in a straight or nearly straight line, head and nape broad and flat above, snout depressed and very broad; anterior dorsal and ventral profiles nearly equal, converging in straight lines at tip of chin; head 3.3 to 3.6 in length in female, 3.6 to 4 in male; interorbital 1.85 to 2.2, width of tip of snout 2.75 to 2.85 in head; eye 3.4 to 3.5 in head in female, 3.1 to 3.3 in male; snout equals or may slightly exceed eye in the female; in the male snout may equal eye but is usually shorter, 3.3 to 4 in head; mouth vertical or nearly so, upper jaw with about forty, minute, laterally inclined teeth in a curved row, which is indented at the middle; at a little distance behind is a band of two rows of very minute teeth, divided into two parts by a central toothless portion, as shown in Plate 2; the lower jaw has a row of about sixty teeth like those above, arranged in two curves with a strongly marked incurved central loop; behind this and separated by a toothless space is a double row of very minute teeth as in the upper jaw, also divided into a right and a left half; three large pores on lower margin of preopercle and four on its posterior margin; scales on top of head larger than those elsewhere; origin of dorsal above pectoral, far in advance of anal and above or in front of ventrals; origin of dorsal sometimes at posterior end of first third of body in males and always well forward in the anterior half; in females it

never begins so far forward and sometimes is midway between tip of snout and base of dorsal; in females the longest dorsal ray is 2 or 2.2 times in head, the posterior rays little if any elongated; in males the dorsal is much more developed, first dorsal spine 2 in head, the rays longer, posterior rays successively elongated, the next to the last one longest, equal to head or to depth; least depth of caudal peduncle about 1.2 or 1.4 times in head; caudal broadly rounded, equal or nearly equal to head; pectoral a little shorter than caudal; in females origin of anal beneath posterior part of dorsal, opposite eleventh scale in the longitudinal series, and far behind pectoral; in males its origin is beneath anterior part of dorsal, beneath posterior half of pectoral and opposite eighth scale in the longitudinal series; origin of anal seven scales behind that of ventrals in females, four scales in males; anal shorter in females than in males, its base tumid and elevated in males, the longest modified ray in males 0.7 or 0.8 of length of head; six ventral rays, but apparently only five in males, second and third rays fused and elongate; the elongate modified ventral ray in males extends over half of anal; about 1.4 times in head; ventral shorter in females, more than twice in head; an enlarged scale covers the angle between the two ventrals; gill rakers 24 on outer arch, 28 on inner arch; peritoneum shining black.

Color silvery to brownish, dusky above, belly yellowish or whitish; some specimens have more or less yellow below dorsal and behind eyes, and also on caudal peduncle; opercle bright silver in females, dark in males; each scale with a black or yellow spot, except on breast and belly, these forming seven to nine longitudinal rows; males with eight vertical bluish dusky bars, the posterior ones often disappearing; rarely they are present on females; dorsal with three or four longitudinal or diagonal rows of circular black spots, and in males with an orange margin; caudal gray in females; caudal orange in males, with a broad black margin and several partial crossbars of blackish spots; other fins colorless or like body.

Here described from a study of 774 specimens, 13 to 48 millimeters in length, obtained from fishponds and salt ponds near Obando, Bulacan Province, Luzon, where this fish is exceedingly abundant. I also have 168 specimens from a salt-water creek at Malolos and a few from fishponds near Malabon. In the catching ponds of bañgos fishpond systems in the above-mentioned localities I have seen many tens of thousands of bubuntis in a single great shoal. From such a mass at least five thousand may

be scooped up in one stroke of a large long-handled dipnet. It is easy to see how harmful these defenseless little fishes really are to the financial well being of the fishpond owners, and how difficult it is for the young bañgos fry to get their living under the fierce competition with swarms of full-grown bubuntis.

Specimens 30 millimeters long are sexually mature. Males rarely reach a length of more than 35 millimeters, and never grow to the size attained ordinarily by females. Collections made during the latter part of May contained many females full of eggs, which had an average diameter of 2 millimeters. The number of eggs is variable, even in fishes of the same size. A specimen 42 millimeters long contained 75 eggs; one 46 millimeters long had 64 eggs, and another 44 millimeters in length had only 55 eggs. A few specimens had embryos nearly ready for birth; a female 32 millimeters long contained 24 embryos almost mature. The coiled embryos are about 3 millimeters in diameter when nearly ready for delivery. The anal opening in females is separated by a comparatively wide space from the opening of the oviduct, which is at the base of the first anal spine.

ILLUSTRATIONS

[Drawings by Pablo Bravo.]

PLATE 1. MOLLIENISIA LATIPINNA LE SUEUR; × 4

PLATE 2. MOLLIENISIA LATIPINNA LE SUEUR

FIG. 1. Teeth of upper jaw.
2. Teeth of lower jaw.
3. Upper pharyngeal teeth.
4. Lower pharyngeal teeth.
5. Ventrals of male.
6. Anal of male, enlarged.
7. Anal, greatly enlarged.
8. Male, dorsal aspect of head.

PLATE 3. MOLLIENISIA LATIPINNA LE SUEUR

FIG. 1. Adult female, lateral view; × 1.5.
2. Adult female, with eggs; × 1.5.
3. Adult female, with embryos ready to deliver.
4. Female, dorsal aspect of head.
5. Embryos.

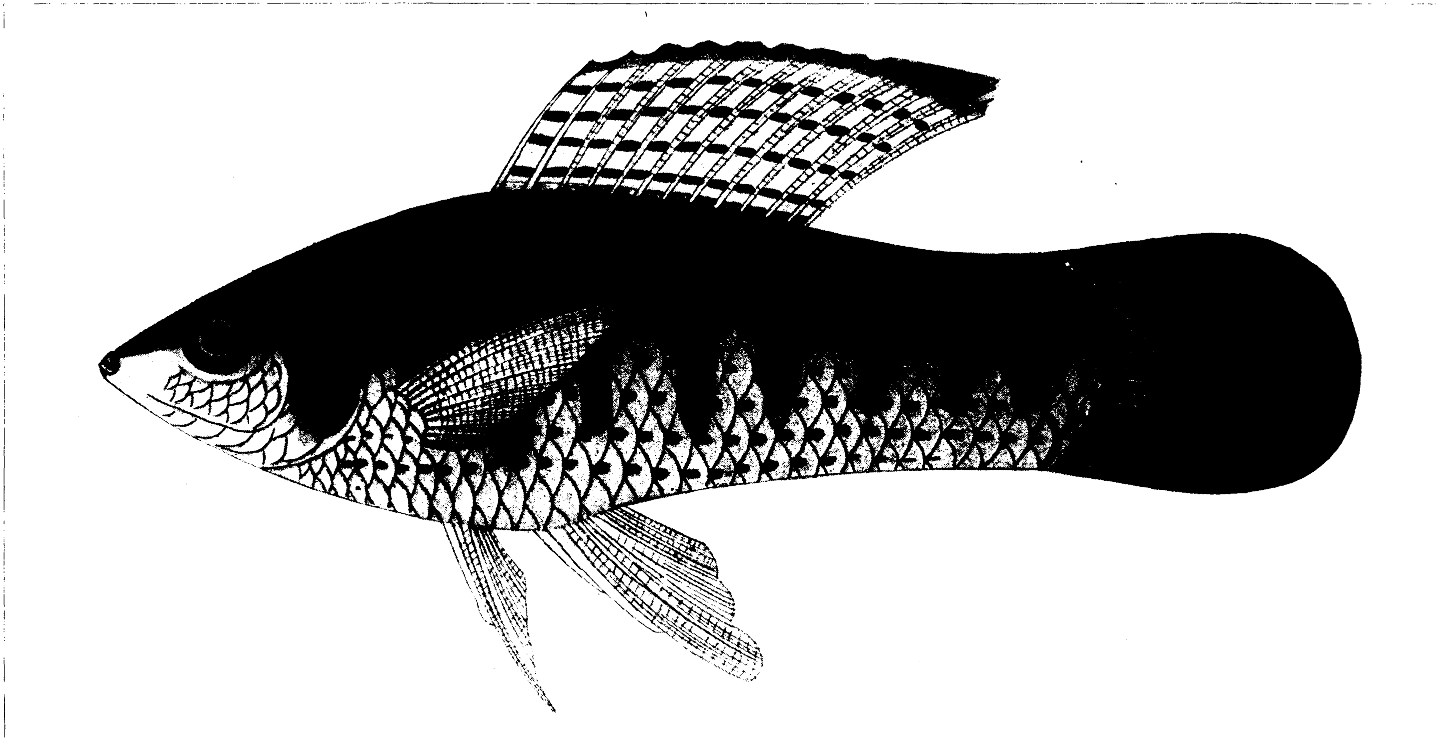

PLATE 1. MOLLIENISIA LATIPINNA LE SUEUR.

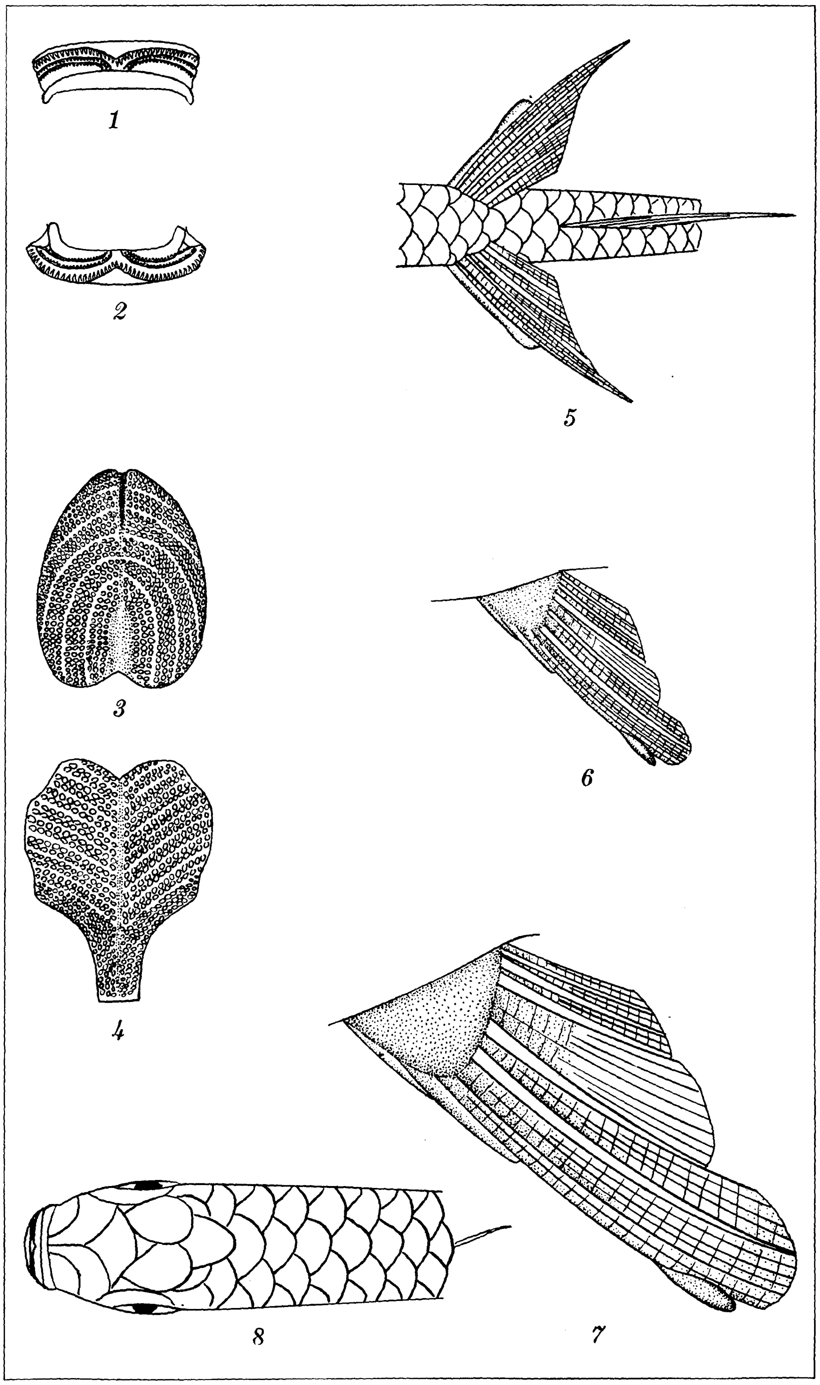

PLATE 2. MOLLIENISIA LATIPINNA LE SUEUR.

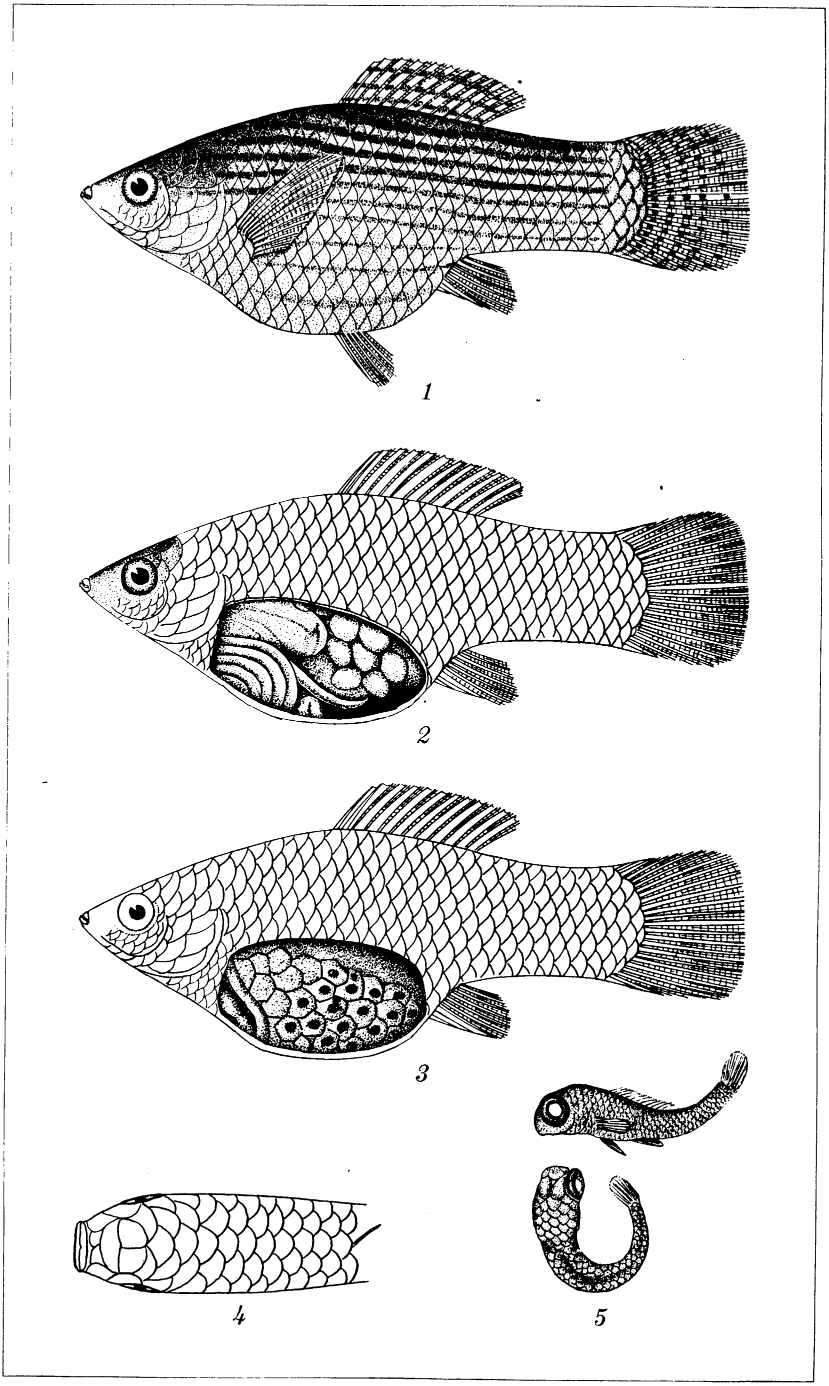

PLATE 3. MOLLIENISIA LATIPINNA LE SUEUR.

NEW OR INTERESTING FERNS

By E. B. COPELAND

Of Chico, California

FIVE PLATES

CYATHEA GIBBSIAE Copeland, nom. nov.

Polybotrya arfakensis GEPP, in Gibbs, Dutch NW. New Guinea (1917) 71, pl. 4.

This species was born to science, as just indicated, in 1917, and enjoyed a hectic babyhood. In the following year, van Alderwerelt [1] based on it a new genus, *Thysanobotrya.* After hardly more than another year, Brause [2] reduced it, generically and specifically, to *Cyathea biformis* Copeland, Philip. Journ. Sci. § C 6 (1911) 364, *Alsophila biformis* Rosenstock, Fedde's Repert. 9 (1911) 423.

Like Brause, I have not seen it, but van Alderwerelt's figures make its nature perfectly plain; I do not believe that it is specifically identical with *C. biformis.* Of this, I have the excellent specimen collected by Mr. King for study; the one described by Rosentock is evidently a much less perfect duplicate. There is no note to show that it was scandent, and I did not so suspect, until Brause described a series of scandent species clearly nearly related to it. The true trunk, near the upper end, is hardly 15 millimeters in diameter, this being approximately doubled by the outside layer of roots and scales, and still further increased at the top by the appressed bases of the stipes. It is somewhat flattened on one side, strengthening the probability that it grew against a tree trunk. The stipes and rachises are black rather than dark purple, though Rosentock and Gepp agree on the latter term. The stipes are appressed to the trunk for perhaps 10 centimeters. From the point where they begin to spread, it is only a few centimeters to the lowest pinnæ, which are less than 10 centimeters long, and sterile. The stipe and a considerable part of the main rachis are clothed on the upper side with persistent, narrow, chestnut scales, 8 to 10 millimeters long. The sterile pinnules reach a length of fully

[1] Bull. Jard. Bot. Buit. II No. 28 (1918) 66, pl. 10.

[2] Hedwigia 61 (1920) 401.

10 centimeters, and bear on the under surface sparse, but rather persistent, small, lanceolate-ovate scales. On my specimen, at least, the dimorphism is of the pinnules, not of the pinnæ. Because Gepp described his plant as different in almost all of the features just noted, I think that the two must be specifically different; but they are surely very closely related. Since he used the same specific name for this plant and also in *Cyathea* and in *Alsophila*, a new one becomes necessary; I name it after Miss Gibbs, the collector, in appreciation of her several important contributions to our knowledge of the mountain vegetation of the Island World.

While the treatment received by *Thysanobotrya* illustrates the natural consequence of generic description while the "true systematical place is uncertain," by those who esteem discussions of phylogeny too trivial to be fit for publication, the fact remains that this is the generic name this plant, and the considerable number of its recognized near relatives, may bear. The affinity of this group of exindusiate species to the group that includes the type of *Alsophila* is decidedly remote. Those of us who are guided by affinity, more than by the chance possession of some arbitrarily selected common characteristic, in the recognition of genera, may place this species in *Cyathea*, or in *Thysanobotrya*, but not possibly in *Alsophila*. In this particular case, there happens to be another alternative. Blume long since proposed a distinctive name for the group of exindusiate species to which this one is directly related—*Gymnosphaera*, Enumeratio (1828) 242. Within *Cyathea*, this is one of the most clearly marked groups of species.

CYATHEA LEUCOSTEGIA Copeland, sp. nov.

Adsunt pinnæ mediales; rhachi frondis 15 mm crassa, spinulosa, sub tegmine furfuraceo fusco atropurpurea; pinnis 40 cm longis, ca. 18 cm latis, abrupte acuminatis, stipitibus earum ca. 2 cm longis, rhachibus superne bisulcatis fulvo-strigosis, inferne asperis atropurpureis decidue furfuraceis; pinnulis sessilibus, infimis 5 cm longis, medialibus fere 10 cm longis, 18–20 mm latis, proximis, acuminatis, rhachillis superne strigosis, inferne deorsum paleis ovatis 1 mm longis albo-stramineis castaneo-ciliatis et apiculatis, et aliis minutis fulvis irregularibus vestiutis, sursum glabrescentibus; pinnulis $^{\text{II}}$ ca. 7-paribus stipitulatis, sequentibus adnatis, solummodo sterilibus minoribus paucis subapicalibus confluentibus, liberis fere 10 mm longis, 2.5–3 mm latis, obtusis, rectis vel subfalcatis, sursum serratis, deorsum crenulatis, basibus acroscopice hastulato-truncatis basiscopice

truncato-rotundatis, subcoriaceis, superne atroviridibus glabris, inferne pallidus viridibus costis deorsum paleis parvis ovatis stramineis ornatis; soris magnis, medialibus, indusiis albidis etiam fissis persistentibus.

CAMIGUIN DE MINDANAO, *Bur. Sci. 14878 Ramos,* 1912.

CYATHEA LEYTENSIS Copeland, sp. nov.

Affinis et similis speciei praecedenti, qua differt: Pinnis subsessilibus, 60 cm longis, 20 cm latis; squamis rhachillarum brevioribus, minus conspicuis, albo-ciliatis; pinnulis II liberis sessilibus utroque latere hastato-truncatis, ubique crenatis vel crenato-lobatis et vix ad apices serratis; indusiis fulvo-stramineis.

LEYTE, Dagami, *Bur. Sci. 15268 Ramos,* 1912.

This and the preceding species are related to each other more nearly than to any species previously described. The conspicuously crenate secondary pinnules of *C. leytensis* suggest *C. fructuosa,* which is found in Leyte as well as in Negros; but that species, aside from less-conspicuous distinctions, has notably darker indusia and paleæ; also, its indusia tend, in rupturing, to leave large, regular cups, while the thinner indusia of these species crumple irregularly.

CYATHEA DEUTEROBROOKSII Copeland, nom. nov.

Cyathea brooksii COPELAND, Philip. Journ. Sci. § C 6 (1911) 135, pl. 16, non *C. brooksii* MAXON, 1909.

Alsophila sarawakensis C. CHRISTENSEN, Index Suppl. (1913) 5, non *Cyathea sarawakensis* HOOKER, 1865.

CYATHEA MELANOPHLEBIA Copeland, sp. nov.

Trunco, teste Ramos, 2 m alto, 10 cm crasso; stipite sursum 15 mm crasso, spinis validis acutis 1–2 mm longis munito, aliter ignoto; rhachi castanea; pinnis infimis ca. 15 cm longis, stipitatis, bipinnatis, non deflexis; medialibus 50 cm longis, 16–20 cm latis, subsessilibus, rhachibus castaneis, solummodo deorsum minute asperulis, decidue castaneo-furfuraceis mox glabrescentibus; pinnulis usque ad 10 cm longis et 25 mm latis, subsessilibus, caudatis, rhachillis primo paleis et squamulis sparse vestitis, mox glabris; pinnulis II infimis sessilibus, sequentibus adnatis, plerisque ala angusta confluentibus, lineari-oblongis, ca. 13 mm longis, 3–4 mm latis, inter se 2 mm distantibus, obtusis, ubi soriferis ibidem bullato-crenatis, ad apices serratis, coriaceis, costis inter soros sparse paleatis, aliter glabris, superne fere nigris, inferne olivaceis, venulis inferne conspicue nigris; soris utroque latere costæ usque 8, paginam fere complentibus, indusiis castaneis, nitidis, sat persistentibus.

LUZON, Nueva Vizcaya Province, Mount Alzapan, altitude 1,500 m. s. m., *Bur. Sci. 45639 Ramos and Edaño.*

This has some resemblance to *C. tripinnata* and *C. callosa,* but is not clearly related to either. The somewhat bullate shallow lobes of the fertile pinnules suggest also the Javan *C. oinops.*

CYATHEA CAMPBELLII Copeland, sp. nov.

Trunco et stipite ignotis; rhachi valida, castanea, minute asperula, glabrescente, aerophoro conspicuo ad basin pinnae quaeque ornata; pinnis majoribus 30–40 cm longis, 10–13 cm latis, sessilibus, abrupte ad apicem pinnatam contractis, rhachibus deorsum inferne glabrescentibus, primo et alibi dense fulvo-furfuraceis et sparse paleatis, superne ubique dense strigosis; pinnulis contiguis vel imbricatis, sessilibus, vix caudatis, rhachillis inferne deorsum paleis (1) albidis lanceolatis 2 mm longis deciduis, (2) minoribus ovatis fuscis sub albidis adspersis, et (3) squamulis, minutis obscuris amorphis ornatis; pinulis II infimis paucis sessilibus, sequentibus adnatis, plerisque ala angusta confluentibus, usque ad 1 cm longis sed plerumque brevioribus, vix 2 mm latis, falcatis, apice rotundatis, integris, coriaceis, superne atroviridibus, inferne fusco-olivaceis; costis deorsum inferne paleis atris parvis dense obtecto, deinde squamulis minutis fulvis vestito, pinnulis alibi glabris; venulis inconspicuis, aut apud costas furcatis aut simplicibus; soris costalibus, indusio incerto.

LUZON, Benguet Subprovince, Mount Bulusan, altitude ca. 2,500 m. s. m., *Copeland s. n.,* 1913.

There are only a few sori on my specimens; they were collected in a storm, and the black paleæ on the costæ look to the naked eye like copious sori. In its display of very diverse paleæ, this is one of the most remarkable ferns of the genus, especially when it is noted that the main axes are glabrescent. *Cyathea fuliginosa,* of the same region, has also diverse paleæ, but none so white or so black as are found on this species. It is named for Prof. D. H. Campbell, eminent in the study of the morphology of ferns, who was my companion on the trip when it was found.

CYATHEA URDANETENSIS Copeland, sp. nov.

Trunco, teste Elmer, 3 m alto, 12 cm crasso; fronde 3 m longa, tripinnatifida; rhachi 15 mm crassa, spinosa, fulvo-castanea et nigro-maculata, paleis stamineis parvis lanceolatis mox deciduis ornata; pinna mediale longe (6 cm) stipitulata, 40 cm longa, 20–25 cm lata, rhachi deorsum aspera, inferne furfuracea, superne canaliculata et ibidem minute fusco-strigosa; pinnulis approximatis, subimbricatis, pedicellatis, medialibus 10–13 cm lon-

gis, 3–3.5 cm latis, horizontaliter patentibus, basiscopice cordatis, sensim acuminatis non caudatis, $\frac{3}{4}$ ad costam pinnatifidis, potius papyraceis quam coriaceis, costis inferne glabrescentibus, pinnulis infimis minoribus et deflexis; lobis contiguis, abrupte falcato-acutis, integris; indusio castaneo, tenue sed persistente.

MINDANAO, Agusan Province, Mount Duros, altitude 800 m. s. m., *Elmer 13473*, August, 1912.

Nearly related to *C. integra* J. Smith, of which I once regarded it as a form.[3] That species has always much laxer fronds, with smaller, much narrower, firmer, obtuse or subacute pinnules, standing well apart, instead of imbricate or in contact; their lobes likewise stand well apart, while in *C. urdanetensis* they are in contact for the most of their length. Typically, the lobes of *C. integra* are entire and blunt, but in these respects the species is variable. In my specimen of Robinson's Bureau of Science No. 6851, from Polillo, which is probably a cotype of *C. hypocrateriformis* v. A. v. Rosenburgh, some lobes are serrate and some are quite entire.

CYATHEA ARGUTA Copeland, sp. nov.

Trunco, teste Ramos, 2 m alto, 10 cm crasso; stipite 60 cm longo, atropurpureo, nitido, deorsum paleis crinitis linearibus albo-stramineis 8 cm longis vestito et fulvo-furfuraceo, ibidem spinis 5 mm longis tenuibus acutis atris deflexis armato, sursum rhachibusque glabrescentibus et spinis fere carentibus; fronde ovata, deorsum paullo angustata, tripinnatifida; stipitibus pinnarum medialium 3–4 cm longis; pinnis iisdem 55 cm longis, 25 cm latis, abrupte acuminatis; pinnulis remotis, usque ad 17 utroque latere, stipitulatis, subcordatis, acuminatis vel subcaudatis et apices versus argute grosse serratis, deorsum $\frac{3}{4}$ ad costam pinnatifidis, ca. 11 cm longis, 2 cm latis, infimis vix minoribus, costis inferne pilis fulvis et squamulis minutis amorphis sparse vestitis, superne minute fusco-strigosis; lobis contiguis, 8 mm latis, falcatis, obliquis, externe serratis, in dentem spiniformem terminantibus, tenuiter coriaceis, superne atroviridibus, inferne olivaceis; indusiis fuscis, persistentibus.

LUZON, Tayabas Province, Mount Alzapan, altitude 1,200 m. s. m., *Bur. Sci. 45727 Ramos and Edaño* (type); Casiguran, *Bur. Sci. 45314 Ramos and Edaño.*

This is a relative of *C. integra* J. Smith, from which it differs in the darker and more shining axes, smoother except at the base of the stipe, more ample foliage, thinner texture, darker upper

[3] Leaflets of Philip. Bot. 5 (1913) 1680.

surface (blackish rather than lurid), acuminate pinnules very conspicuously toothed near the apex, and broader but less separate lobes, serrate with spinelike points. *Cyathea integra* is one of the few tree ferns found throughout the length of the Philippines. Recognizing it as variable, I have still imperfect specimens of what I regard as several more related species.

CYATHEA SESSILIPINNULA Copeland, sp. nov.

Trunco ignoto; stipite ultra 30 cm longo, deorsum spinuloso, sursum rhachibusque inermibus, fuscis, linea dorsale strigosa excepta glabris; fronde vix 1 m longa, ovata; pinnis infimis deflexis, 10 cm longis; medialibus 25–30 cm longis, vix 10 cm latis, fere sessilibus, acuminatis; pinnulis sessilibus, acumunatis, rectis vel falcatis, 5 cm longis, ca. 13 mm latis, ad vel ultra median laminam pinnatifidis, infimis vix minoribus, costis, inferne pilis fuscis minutis ornatis; lobis 3–4 mm latis, non contiguis, falcatis, integris, plerisque obtusis, subcoriaceis, glabris, superne atroviridibus, inferne olivaceis; indusiis fuscis, persistentibus.

BASILAN, *Bur. Sci. 16212 Reillo*, 1912.

One of the group of *C. integra*, as shown by color of axes and lamina, and the form and dissection of the frond; but clearly distinguished by smallness and slenderness, sessile pinnules and subsessile pinnæ. In color it is like *C. arguta.*

CYATHEA HETEROLOBA Copeland, sp. nov.

Trunco, teste Ramos, 3 m alto, 6 cm crasso; stipite breve, infra pinnas infimas remotas pinnatas 4 cm longas 15–20 cm longo, ad basin sub paleis linearibus castaneis nitidis occulto, sursum rhachique sordide furfuraceis, minute asperis, sordide fulvis; fronde 90 cm longa, 40 cm lata, utrinque angustata; pinnis sessilibus, medialibus maximis, 20–25 cm longis, 6–7 mm latis, acutis, rhachibus squamulis amorphis et praecipue sursum paleis subbullatis minutis albidis vestitis; pinnulis approximatis, sessilibus, obtusis, 3–3.5 cm longis, ca. 7 mm latis, majoribus ad rhachin pinnae pinnula " una (rarius duo) libera orbiculare praeditis, deinde leviter lobatis et ultra mediam longitudinem solummodo leviter oblique crenulatis, papyraceis, superne obscuris, inferne pallide olivaceis, costis praecipue deorsum paleis minutis subbullatis albis ornatis; soris medialibus; indusio fusco, mox disrupto et praeter discum basalem irregularem evanescente.

LUZON, Nueva Vizcaya Province, Mount Alzapan, altitude 1,500 m. s. m., *Bur. Sci. 45633 Ramos and Edaño.*

Probably a relative of *C. philippinensis* and *C. robinsonii,* but one of the most distinct species in the genus. The small

pinnules, almost entire in their distal halves but cut to the costa at their bases, are quite unique.

CYATHEA PSEUDALBIZZIA Copeland, sp. nov.

Trunco, teste Ramos, 1 m alto, 4 cm crasso; stipite 30 cm longo, ad basin paleis anguste linearibus ferrugineis sub lente cinereis minute ciliatis dense vestito, sursum rhachique fuscis, densissime minute tuberculatis, fusco-furfuraceis, 6 mm crassis; fronde 60 cm longa, late ovata; pinna infima 15 cm longa; mediale 30 cm longa, ca. 12 cm lata, copiose bipinnata, stipite 2–3 cm longo, pinnulis hujus infimis longe (5–10 mm) stipitulatis, medialibus subsessilibus, usque ad 7 cm longis, 12 mm latis, sensim acuminatis, costis inferne dense paleaceis, paleis castaneis difformibus; pinnulis ^{II} remotis, infimis brevissime pedicellatis orbiculari-oblongis rotundatis, superioribus adnatis obliquis plerisque acutis, integris, ad costas et venulas inferne piliferis, rigide coriaceis, superne nigris, inferne fusco-viridibus.

LUZON, Isabela Province, Mount Moises, altitude 1,150 m. s. m., *Bur. Sci. 47350 Ramos and Edaño.*

Another member of the group of *C. philippinensis,* nearer to *C. robinsonii* than to any other species previously known.

DRYOPTERIS WEBERI Copeland, nom. nov.

Dryopteris dichrotricha COPELAND, Philip. Journ. Sci. § C 7 (1912) 54, non COPELAND, Philip. Journ. Sci. § C 6 (1911) 74.

The two ferns to which I gave the same name, only a year apart, are not at all alike and were not thought to be. In spite of quite illustrious precedents for this carelessness, it seems to me inexcusable.

DRYOPTERIS BAKERI (Harrington) Copeland.

Dryopteris bakeri (Harrington) COPELAND, Philip. Journ. Sci. § C 2 (1907) 405.

Nephrodium bakeri HARRINGTON, Journ. Linn. Soc. Bot. 16 (1877) 29.

To this species, hitherto known from Panay and Negros, I am now referring collections from northern Luzon, *McLean and Catalan 95,* from Claveria, Cagayan Province. This is in part larger than the species as known before, with fronds up to 20 centimeters long and 3 centimeters wide. The basal pinnæ of smaller fronds are as originally described, not larger than the lobes which follow them; but on the larger fronds these pinnæ are up to 3 centimeters long, obovate with broadly truncate base, and shallowly lobed. There may be a second pair of free pinnæ, but these are not enlarged or but slightly so. Except that the veins are simple, and supplementary areolæ are therefore wanting, this would be *Haplodictyum majus.*

DRYOPTERIS CESATIANA C. Christensen.

Dryopteris oblanceolata COPELAND, Philip. Journ. Sci. § C 9 (1914) 3.

King 477, from the mountains behind Wedan, Papua, is this species, but is much larger than the specimen originally described. The tips are missing from the largest fronds, but these have stipes up to 10 centimeters long; then a series of five or six pairs of remote, dwarfed, adnate pinnæ, strung along the rachis for 15 centimeters; and the linear-oblanceolate body of the frond is probably considerably more than 40 centimeters long. The fructification covers the lamina completely in places, but more generally is typically meniscioid. The known range is eastward to Fiji.

CYRTOMIUM INTEGRIPINNUM (Hayata) Copeland, comb. nov.

Polystichum integrifolium HAYATA, Icones Fl. Form. 4 (1914) 196, fig. 133.

Faurie 550, from Mount Arisan (the type locality), altitude 2,500 meters, "secus aquas in humidis sylvarum," conforms well to Hayata's description and figures. It has a moderately stout, and only moderately scaly suberect caudex. The lower part of the stipe is almost covered by the persistent bases of otherwise deciduous paleæ.

CYRTOMIUM NEPHROLEPIOIDES (Christ) Copeland, comb. nov.

Polystichum nephrolepioides CHRIST, Bull. Geog. Bot. Mans. (1902) 258.

The transfer to *Cyrtomium* is made on the evidence of Cavelerie's No. 1216.

TECTARIA DOLICHOSORA Copeland, sp. nov.

T. rhizomate erecto, brevi, valido, radicibus multis crassis, basibus stipitum, et ad apicem paleis castaneis linearibus obtecto; stipitibus caespitosis, hic illuc paleis paucis castaneis ornatis, 40–60 cm altis, costisque ebeneis nitidis; fronde cordato-deltoidea, 30–35 cm alta, 20–30 cm lata, profundissime tripartita, segmento mediale utroque latere et segmentis basalibus basiscopice pinnatifidis, subcoriacea, glabra, olivacea; venulis anastomosantibus cum liberis simplicibus vel hamatis inclusis; soris omnibus secus venulas elongatis, 2–5 mm longis, 1.5 mm latis, plerisque rectis; indusiis coriaceis, persistentibus, marginibus ubique liberis.

LUZON, Cagayan Province, Claveria, "steep leeward side of summit of West Mountain," *McLean and Catalan 160,* December, 1919.

The very remarkable sori distinguish this species sharply from all others known in its genus. Elongate sori are not so rare; but the usual tendency, in these as in other ferns, is for the indusium to disappear when the sorus exceeds the usual limits of the group. Except for the sorus, this resembles *T. melanocaulon.*

Bur. Sci. 13828 Ramos, collected in Cagayan in 1912, and long left without a name, seems to be an immature form of this. The frond is much less divided and not quite so large, and the sori are only slightly elongated.

TECTARIA DICTYOSORA Copeland, sp. nov.

Rhizomate ignoto; stipite 40 cm alto, rufo-castaneo, nudo sulcato, rigido, gracile; fronde late ovata, pauci-pinnata, herbacea, superne viride, glabra, inferne olivacea; pinnis uniparibus oppositis, ca. 12 cm longis, 3 cm latis, utrinque angustatis, subcaudatis, margine integris vel undulatis, basi adnatis, et breviter anguste decurrentibus, costa etiam distincte decurrente, glabra; venis inferne minute hirtis; parte mediale frondis trifida, segmentis lateralibus pinis similibus, decurrentibus sed ala insertionem pinnarum non attingente, segmento mediale majore; venulis irregulariter anastomosantibus cum liberis inclusis paucis; soris exindusiatis ad venulas nullibi interruptis, denique interdum parenchyma tamen occupantibus, pilis capitulatis (paraphysibus) inter sporangia dense inmixtis, capitulis eorum plerisque trilobatis lobo quoque hyalino unicellulare; sporangiis nudis.

Canton, collected under Levine's direction in 1917, herbarium of Canton Christian College No. 1949, type in United States National Herbarium.

This was distributed as *Dictyocline griffithii,* with which it shares its most conspicuous feature, the reticulate "sori." The immediate real affinity, however, is not to that fern, but to the exindusiate members of the group of *Tectaria vasta.* With these it shares color, texture, the conspicuous decurrent costæ of pinnæ and segments, and the very characteristic paraphyses. *Dictyocline* also is presumably a tectarid fern, but I do not yet know its source more precisely than that. It has no near affinity to the group of "Vastae."

TECTARIA ASPIDIOIDES (Presl) Copeland, comb. nov.

Heterogonium aspidioides PRESL, Epim. Bot. (1894) 143.
Digrammaria ambigua PRESL, Tentamen (1836) 117.
Tectaria ambigua COPELAND, Philip. Journ. Sci. § C 2 (1908) 415.
For other synonymy see Christensen's Index.

The name *ambigua* is invalid because it did not originate with Presl, as from the citations it seems to do, but is taken from *Asplenium ambiguum* Swartz, which is *Athyrium esculentum*.

TECTARIA BUCKHOLZII (Kuhn) Copeland, comb. nov.

Aspidium buckholzii KUHN, in von Decken, Reis. Bot. (1879) 47.

This Kamerun fern has the anastomosis of the veins conspicuously like that of *T. aspidioides*. Otherwise, they do not seem at all nearly related.

TECTARIDIUM MACLEANII Copeland.

Tectaridium macleanii COPELAND, Philip. Journ. Sci. 30 (1926) 329.

This fern has been collected at Claveria, Cagayan Province, *McLean and Catalan 84*, December, 1919.

ATHYRIUH ALTUM Copeland, sp. nov.

Athyrium A. Merrilli affine rhizomate erecto; stipitibus caespitosis, 6–10 cm longis, fusco-nigris, paleis angustis atro-castaneis vel atris patentibus 2 mm longis dense vestitis; fronde 30 cm alta, lineare, utrinque gradatim angustata, acuminata, pinnatifida, coriacea, superne obscure viride inferne olivacea, costa superne sparse inferne densius paleacea; segmentis medialibus ca. 2 cm longis (a costa ad apicem), 5 mm latis, rotundatis, fere rectis, integris, sinubus 2–3 mm latis separatis, ala 3–4 mm lata connexis, deorsum sensim abbreviatis, infimis quam longis duplo latioribus, non liberis; soris a costula ad marginem protensis; indusio brunneo.

MINDANAO, Agusan Province, Mount Urdaneta, altitude 1,800 m. s. m., *Elmer 14081*, 1912 (type); formerly determined and distributed as *A. merrilli*. LUZON, Tayabas Province, Umiray, *Loher 13618*, 1915.

This differs from *A. merrilli*, which we now have from Basilan (*Bur. Sci., 16187 Reillo*) as well as from Mindoro, in the longer stipes, much longer and narrower frond, with narrower segments, remote instead of contiguous or imbricate, and decidedly firmer texture. Some fronds of Loher's collection are a little broader than here described, and one has a single elongate basal segment, which seems to be a mere freak.

Very conspicuous characters always tend to distract attention from those less salient. This is best shown by the bunching of all the species of isolated genera, such as *Angiopteris*. Differences between *Davallodes* species, so clear that in other groups genera have been distinguished by them, have similarly been refused recognition as of specific value, by those blinded by the common characters of the genus. The group of *Athyrium*

porphyrorachis is likewise so clear-cut as a whole that there is the same natural tendency to regard its members as all one variable species. Once, however, the differences within such a group are recognized, there is no sound reason for denying them the importance granted them in other groups.

ATHYRIUM LONGISSIMUM Copeland, sp. nov.

Athyrium A. porphyrachi affine foliis pinnatis; caudice erecto; stipitibus caespitosis, validis, 5–10 cm longis rhachibusque nigris, paleis patentibus angustis 5 mm longis atris dense vestito: fronde 50 cm alta, lineare, utrinque attenuata; pinnis utroque latere 30–40, medialibus adnato-sessilibus 2.5–3 cm longis, e basi 1 cm lata sensim ad apicem acutam (rarius obtusam) angustatis, basi basiscopice excisis, acroscopice subauriculatis saepe supra rhachim imbricatis, herbaceis, superne atroviridibus, inferne pallidioribus, costulis inferne sparse et interdum venulis sparsissime paleis minutis vestitis; pinnis inferioribus sensim abbreviatis et rotundatis, infimis paullulum remotis, superioribus praecipue acroscopice plus adnatis; venis plerisque furcatis, inter se remotis; indusio nigro.

LEYTE, Dagami, *Bur. Sci. 15269 Ramos,* 1912.

Though clearly related to *A. porphyrorachis, A. merrilli,* and *A. altum,* all with pinnatifid fronds, this is a remarkably distinct species. Except for its conspicuous paleæ, it bears a striking resemblance to *Asplenium longissimum* Blume.

ATHYRIUM BANAHAOENSE Copeland, sp. nov.

Rhizomate erecto vel adscendente, paleis castaneis, 3–4 mm longis, lanceolatis valde attenuatis vestito; stipitibus caespitosis, longioribus ca. 6 cm longis, deorsum nigris, paleis angustis patentibus curvatis vel contortis marginibus sparse spinosis vestitis; rhachi stramineo-viride vel nigrescente, glabrescente, superne utroque latere sub lente angustissime alata; fronde 15–28 cm alta, lineari-lanceolata, utrinque attenuata, infra apicem serratam parte frondis pinnatifida 3–4 cm longa, alibi pinnata; pinnis multis, stipitulatis pecidello cum rhachi coalato 1 mm longo, medialibus maximis vix 2 cm longis, absque auricula 6 mm latis, obtusis, serratis vel inciso-serratis, basi basiscopice cuneatis, acroscopice truncato-auriculatis auricula magna rotundata, firmiter papyraceis, inferne pallido-viridibus, superne obscuris, costa inferne paleis paucis filiformibus caducis praedita, aliter glabris; venis in auriculis pinnatis, alibi plerisque furcatis; soris plerisque diplazioideis; indusiis brunneis.

LUZON, Mount Cristobal, altitude 800 m. s. m., *Copeland s. n.,* May, 1908, type.

Elmer 7965, Mount Banahao, is partly typical, but some plants have browner paleæ and more acute pinnæ. *Elmer 7964*, Mount Banahao, is a dwarf form. *Bur. Sci. 13373 Ramos* has the sori more crowded and the wing of the rachis hardly visible. Because of its reduced but not more deeply cut lower pinnæ, *Boyce 13*, from Tarlac, is referable here rather than to *A. williamsii;* but it has larger and more deeply cut pinnæ than any of our specimens from the Banahao region.[4] The larger fern there referred to is *A. elmeri*, an exindusiate species, hitherto reported only from Mount Canlaon and the Horn of Negros.

San Cristobal, or Cristobal, is the western of three cones making up the Banahao mountain mass. Elmer's specimens come from the eastern one, the Lucban cone. On all three, the fern named for the mountain is common in moist woods at middle elevations. I have tried many times to see that it merges into any other species, but found no such evidence. The reduced lower pinnæ and more-entire pinnæ distinguish it clearly from its immediate relatives. *Athyrium acrotis* (Christ) must be very similar in general appearance, but is described as light green; this might signify little in most groups of ferns, but among these little Philippine athyriums it is always associated with peculiarities of texture and paleæ, and marks the group of *A. grammitoides*.

ATHYRIUM RAMOSII Copeland, sp. nov.

Rhizomate erecto, gracile, paleis minutis nigris vestito; stipitibus caesuitosis, plerisque ca. 12 cm longis, rhachibusque paleis parvis angustis castaneis aspero-marginatis distantibus haud dense vestitis; fronde 15–20 cm alta, lanceolata, apice acuminata pinnatifida, bipinnata, obscure viride inferne paullo pallidiore, tenue sed (sicca) firmiter papyracea, glabra; pinnis brevi-pedicellatis, erecto-patentibus, infimis aequilongis vel paullo quam sequentes majoribus 2 cm longis, 1–1.5 cm latis, obtusis, ovatis, pinnatis; pinnulis infimis pinnarum inferiorum rotundo-oblongis vel váriiformibus, semper apice rotundatis grosse et argute pauci-dentatis, basi cuneatis, interdum cum pinnula[II] una cuneata acroscopica libera; pinnulis aliis obovatis cuneatis, apice rotundatis et ibidem inciso-dentatis, ca. 5 mm longis, 2–4 mm latis; pinnis apicem versus frondis gradatim decrescentibus, angustioribus et simplicioribus; venis paucis, quaque in dentem protracta, dentibus lateralibus saepius incurvatis, apicalibus rec-

[4] See Philip. Journ. Sci. § C 3 (1908) 297, for comment on this and on the plants now named *A. banahaoense*.

tis; soris longis, rarius bilateralibus; indusio brunneo, persistente.

CAMIGUIN DE MINDANAO, *Bur. Sci. 14852 Ramos.*

After many years of observation and copious collection in this group, I am again, rather than still, of the opinion held twenty years ago, that a rather fine discrimination of its species is expedient. If the contrary policy were adopted, this might be construed as a form of *A. geophilum*, a species of the same region, which is typically smaller, more lax in habit but essentially less dissected and less scaly. It is less immediately related to *A. bolsteri*, which, among other differences, has the upper part of the frond cut to a winged rachis for a long distance, while this part of the frond is very short in *A. ramosii.*

This collection is cited by Hieronymus under *Asplenium squamiligerum* (Rosenstock) Hieronymus, Hedwigia 61 (1919) 5, nomen nudum. The name does not have to be conserved, and would invite confusion with *A. squamigerum;* but my chief reason for rejecting it is that I doubt the identity of this and the New Guinea "variety." Rosenstock [5] says, "pinnulis pinnulisque in specimine apice lato, integro desinentibus;" but the toothed apices of *A. ramosii* are one of its conspicuous characteristics.

As to the genus: The mere aspect of this fern shows it unmistakably to be an *Athyrium*, in distinction from *Asplenium.* How Hieronymus could subject the paleæ to careful study and describe them accurately and still not recognize them as characteristic of *Athyrium*, positively so known at least since Milde's time, is incomprehensible.

ATHYRIUM FORMOSANUM (Rosenstock) Copeland, comb. nov.

Diplazium formosanum ROSENSTOCK, Hedwigia 56 (July, 1915) 337.
Diplazium odoratissimum HAYATA, Icones Form. 5 (November, 1915) 273.

In Icones Form. 8 (1919) 145, these two species of *Diplazium* are identified as the same, but under the later name. We have two good specimens of the type collection of Rosenstock's species, *Faurie 188*, 1914, distributed as *Diplazium javanicum* Makino. Faurie seems to have collected the new species and typical *Diplaziopsis* together, which throws just a little doubt on the status of the new species. That is, one might suspect it of being a hybrid, if this were the only collection. The affinity of the two is quite unmistakable. There is a strong resemblance in color, texture, margin, and venation, all peculiar features; and the likewise

[5] Fedde's Repert. 12 (1913) 528.

peculiar fleshy stipes are indistinguishable. Both have thin, fragile indusia, but this is not so extreme in the new species; wherefore, it opens by its margin, breaking elsewhere only exceptionally; whereas, the indusium of *Diplaziopsis* usually breaks open elsewhere to expose the sporangia.

The chance that this is a hybrid was lessened by its independent collection as the type of *A. odoratissimum.*

A smaller plant, which seems specifically indistinguishable from this, is found in Kwangtung, on Loh Fau Mountain, by Levine, McClure, and To (1921), herbarium of Canton Christian College No. 6866.

In the same group clearly belongs *Athyrium heterophlebium* (Mettenius: Baker) Copeland, comb. nov. (*Asplenium heterophlebium* Mettenius MS. in Synopsis Filicum 243). Hayata distinguished his *D. odoratissimum* from this by its not having a toothed margin. The idea of a toothed margin of *A. heterophlebium* comes from Beddome's figure;[6] but the original description, as Beddome correctly copied it, says "the edge undulated," which agrees perfectly with the Formosa plant in its most perfect development. The Kwangtung specimen has the margin entire, as do the smaller fronds from Formosa. If it were not that the rachis is described as "villose and fibrillose throughout," while there is nothing villose about the Formosa and Kwangtung plants, they might all be regarded as one widely distributed species.

The bridging of the gap between *Athyrium* and *Diplaziopsis*, by the species just discussed, is one reason for abandoning *Diplaziopsis* as a genus. They effectively do away with the venation as a distinguishing character, although the identity of venation is not complete. The character taken as essential for *Allantodia* by Baker, and Diels, and thence for *Diplaziopsis* (merely a new name) by Christensen, is the rupturing of the indusium. This might do very well for the critical distinction of an aberrant species or group, if it were constant; but it is not so. In a series of sheets of this fern, of various origins, I find no mature frond in which all the indusia open by rupture instead of by the lifting of the distal margin. Since what has been called *Diplaziopsis* is not separated from other species now known and recognized as *Athyria* by any wider gap than cuts off various other species—*A. accedens, A. opacum, A. esculentum,* for examples—it may properly be treated in the same manner, and known as *Athyrium javanicum* (Blume), *Asplenium javanicum* Blume, Enumeratio (1828) 175.

[6] Ferns Brit. Ind. pl. 329; Ferns Brit. Ind. and Ceylon 192.

ATHYRIUM CAVALERIANUM (Christ).

Allantodia cavaleriana Christ, Ac. Geog. Bot. Mans. (1906) 293, *Diplaziopsis cavaleriana* C. Christensen, from Kweichau, is probably a near relative of *A. javanicum.* The individual pinna at the apex places it here, and distinguishes it from such species as *A. formosanum.* The likeliest clue to the exposure of the sporangia should be the genus in which Christ places it. What he says is: "Indusio nigro opaco et adiaphano carnosulo initio clauso mox corrugato sporangiisque occulto." One of the sori figured seems to show a diplazioid form and to be exposed by the lifting of both distal margins. The species should be known as *Athyrium cavalerianum* (Christ).

LINDSAYA FISSA Copeland, sp. nov. Plate 1.

Rhizomate scandente, ramoso, 2 mm crasso, atrocastaneo, paleis castaneis integris lanceolatis deciduis basibus adnatis 2 mm longis subvestito; stipitibus remotis, gracilibus, 1–4 cm longis ad basin atrocastaneis nitidis paleis minoribus caducis sparisius vestitis, sursum, rhachique plerumque laete stramineis, rarius etiam plus minus castaneis; fronde usque ad 40 cm alta, 3 cm lata, utrinque angustata, profunde bipinnatifida, herbacea; pinnis brevissime stipitulatis, dimidiatis, subcontiguis, 15 mm longis, 5–7 mm latis, recurvatis, margine superiore-exteriore profunde incisis, segmentis plerumque ca. 5, obovato-cuneatis, truncatis, apicibus aut subintegris aut irregulariter minute denticulatis; venulis tenuibus in segmentis furcatis et in segmentis inferioribus latioribus bis furcatis; soris quoad segmenta terminalibus, fere omnibus compositis; indusio rarius (sororum simplicium) Microlepioideo, plerumque lato et breve, margine crenulato, apicem segmenti non attingente.

PALAWAN, Mount Capoas, *Merrill 9527,* type in herbarium Copeland No. 7114; *Merrill 9535,* this specimen, whether or not naturally, dark-colored throughout.

This species is intermediate between *L. hymenophylloides* Blume and *L. repens* (Bory) Beddome. It is to be observed that, although both of these names are familiar, the plants themselves are much less positively so. As to *L. repens,* Brause,[7] presumably with knowledge of authentic material, says that it is known only from Mauritius and Reunion; that the *L. repens* of Beddome, Ferns So. Ind. pl. 209 (he does not mention pl. 214), is *L. pectinata;* and that the similar species common in the Philippines is a distinct one, which he calls *L. boryana* (Presl). Assuming the distinctness of the Philippine plant in question,

[7] Engler's Jahrb. 56 (1920) 129.

I do not see how it can bear Presl's name. For reasons not clear, he used a new specific name for *Dicksonia repens* Bory, identifying with it a Philippine specimen. Although his citation of synonymy is preceded by a brief diagnosis, based on the Philippine specimen, his choice of a specific name makes it clear, along with the citation, that he was not describing a new species. In the Tentamen (under *Saccoloma*) he cites both names, *repens* as the synonym. Finally, in the Epimeliae, this time under *Odontoloma,* he took cognizance of priority, and made *D. boryana* a synonym of *O. repens.*

Christ was disposed to make one species of this whole group, including also *L. hymenophylloides;* but I believe he attached a very undue importance to the occurrence of dissected fronds on supposed juvenile specimens of species whose adult plants bear entire or shallowly lobed pinnæ. They are interesting as clues to phylogeny, but do not prove anything like specific identity; gastrula and blastula stages of his embryo do not make a polyp of a fish or a man. Whether or not the Philippine fern called *Davallia boryana* by Presl ranges to India, or even to Mauritius, neither *L. hymenophylloides* nor *L. fissa* is that species. Even if *D. boryana,* under whatever name, becomes unusually dissected, so as to include forms cut more than half-way across the pinna, as is *Loher 13621,* from Tayabas, *L. fissa* is still distinct, more deeply cut, thinner, the sori farther from the margin and more uniformly composite, and the segments divaricate.

It is nearer to *L. hymenophylloides.* If we had only the original diagnosis,[8] I might, in spite of the "laciniis linearibus," identify it as that species. But a common Philippine fern fits Blume's diagnosis in its entirety, and is readily distinguished from *L. fissa* by its very much narrower and more uniform segments, with the sori usually simple. It seems not to be common in Java; for it was known to Hooker only by description when he issued the first volume of the Species Filicum, and is not mentioned by Raciborski. Whether *Davallia hymenophylloides* Baker, Icones Pl. III 7, pl. 1623, as figured, is another species, or a distorted drawing, I do not know. The figure shows the segments, as well as the pinnæ, very one-sided, which is a condition not even suggested by Steere's Luzon plant, cited in the text.

LINDSAYA RAMOSII Copeland, sp. nov. Plate 2.

Rhizomate brevi-repente, vix 2 mm crasso, pilis fusco-castaneis minutis (0.5 mm longis) vestito; stipitibus approximatis, fulvis, nudis, gracilibus, frondum simpliciter pinnatarum fertilium 7 cm,

[8] Enumeratio 218.

bipinnatarum 25 cm altis; frondibus aut pinnatis 15–20 cm altis vix 15 mm latis acuminatis deorsum non angustatis, aut compositis, cum ramis similibus sessilibus (in specimine Ramosii utroque latere uno) lateralibus paullo minoribus rhachibus gracilibus stramineis; pinnis (resp. pinnulis) approximatis et saepe imbricatis, breviter stipitulatis, late oblongis, majoribus ca. 7 mm longis, 4 mm latis, herbaceis, integris, marginibus inferiore et interiore (rhachin versus) rectis, exteriore truncato-rotundatis; venis subflabellatis, sparsissime anastomosantibus, inconspicuis; soro continuo, indusio angusto, cum margine pinnæ fere continuo.

LUZON, Cagayan Province, *Bur. Sci. 7562 Ramos*, type in herbarium Copeland No. 7118.

Related to *L. borneensis* Hooker, rather than to any species of the "Synaphlebium" group, to which the sparingly anastomosing veins would indicate a reference; probably, too, not very remotely related to *L. concinna* J. Smith. By a key, it falls with *L. azurea* Christ, but is very different in venation, judging by Christ's figure,[9] not bluish, stipes not appreciably rigid, and the fronds or their branches broad to the base.

McLean and Catalan 89, from Claveria, Cagayan, represents the same species. The fronds of this collection are all composite (bipinnate), with more-numerous and slenderer branches—one or two on a side, and 8 to 10 millimeters wide.

LINDSAYA CONCINNA J. Smith.

Schlechter 19900, 1909, from Kaiser-Wilhelms Land, distributed as *L. gracilis* Blume, is not that species, but may be identified as *L. concinna*, from which it differs, if at all, in its shiny upper surface. It differs from *L. brevipes* in the base of the frond, which is not long-attenuate. There are other reports of *L. gracilis*, which may be correct.

LINDSAYA MICROSTEGIA Copeland.

Lindsaya microstegia COPELAND, Philip. Journ. Sci. § C 6 (1911) 83.

Schlechter 17133, from Kani Mountain, Kaiser-Wilhelms Land, distributed as *L. repens*, is *L. microstegia*. The indusium is less than 0.1 millimeters long, and is usually invisible after the sporangia begin to mature. Quite aside from the character of the indusium, it is very distinct from *L. repens*.

LINDSAYA LONGIFOLIA Copeland, sp. nov. Plate 3.

Synaphlebium terrestre: rhizomate breve, radicoso, 2–3 mm crasso, paleis fuscis parvis vestito; stipitibus caespitosis, 15–20

[9] Ann. Buit. 15 (1897) 101, pl. 14, fig. 12.

cm altis, rhachibusque nudis, gracilibus, sulcatis, fulvo-stramineis; frondibus bipinnatis, pinna terminale 15–20 cm vel ultra longa, ca. 1 cm lata, utrinque sensim angustata, pinnis lateralibus utroque latere 1–3, paullo minoribus; pinnulis herbaceis, brevistipitulatis, inferioribus et superioribus multis deltoideo-cuneatis, medialibus obliquioribus, contiguis et saepe imbricatis, margine interiore 4 mm longa rhachi parallela et approximata rectis, inferiore fere 7 mm longa leviter sursum-curvatis, superiore plerumque ca. 5 mm longa plus minus curvatis et incisis, basi cuneatis; venis fere occultis, paucis, flabellatis, anastomosantibus; soris pinnularum medialium saepius 3, compositis, pinnularum superiorum et inferiorum saepius solitariis apicem totam occupantibus; indusio laete, tenue, breve, sed cum margine conterminante.

BASILAN (prope Mindanao), *Bur. Sci. 16227 J. Reillo,* 1912, type in herbarium Copeland No. 7126.

This seems to be a decidedly distinct species. It has the frond form of a slender *L. borneensis,* but differs in venation and in the shape of the pinnules. While the description has much in common with that of *L. decomposita,* I doubt their being very nearly related.

CRASPEDODICTYUM CORIACEUM Copeland, sp. nov.

Species ex C. quinato segreganda, rhizomate 8 mm crasso, lignoso, breve; stipitibus confertis, 30–50 cm altis vel altioribus, deorsum castaneis, paleis paucis deciduis atrocastaneis ovatis 1 mm longis rigidis ornatis, sursum brunneis, nudis, superne sulcatis; fronde trifoliata, glabra, coriacea, superne atroviride, inferne olivacea; pinnis integris, acuminatis, mediale 20 cm longa, 5 cm lata, brevissime pedicellata, lateralibus paullo minoribus, adnatis, interdum at basin gemmiferis; venis inconspicuis, seriem unam areolarum marginalium efficientibus. Frons fertilis deest.

SUMATRA, Benkoelen, Legong Tandai, *C. J. Brooks 191S,* April, 1913.

This is probably the same as the Bornean component of *C. quinatum* (*Gymnogramme quinata* Hooker, Spec. Fil. 1: 152), providing the first part of "subcoriaceo-membranaceous," the second part of "quinato-pedato," and the "ternate" and "decurrent at the base," the contrasting features of the description being provided by a Polynesian fern. I have from Papua what I suppose is the latter, and construe it as typical *C. quinatum* because Hooker cited the Oceanic collections first. The two are as distinct as two species of a genus ever need to be.

CRASPEDODICTYUM SCHLECHTERI (Brause) Copeland, comb. nov.

Syngramme schlechteri BRAUSE, Engler's Jahrb. 49 (1912) 32.

This is distinguishable from *C. grande*, published a year earlier, by having its veins much less crowded, and the lateral pinnæ short-stalked, instead of decurrent. As to the specimens in hand, the most conspicuous difference is that *C. grande* is trifoliolate, while this species has five leaflets.

CRASPEDODICTYUM MAGNIFICUM Copeland, sp. nov.

C. vero magnificum; stipite valido superne late et profunde canaliculato, fusco-stramineo; lamina more generis quinque-foliolata, glabra, tenuiter membranaceo, angustissime hyalino-marginata, costis utroque facie praecipue inferne rotundato-prominentibus; foliolis acuminatis, decurrentibus, mediale ultra 50 cm longa, 7 cm lata, medialibus paullo minoribus (45 x 7 cm), lateralibus 25–30 cm longis, 6.5 cm latis; venis ca. 1.7 mm inter se distantibus, conspicuis, castaneis, areolarum marginalium minorum series secunda hinc inde efformata, vena longitudinale reticulationi finem imponente intramarginale.

New Caledonia, lectore ignoto. Type in herbarium of the California Academy of Science.

The largest known species, and the thinnest. I am construing as *C. quinatum* a fern which exemplifies the aspects of Hooker's diagnosis that do not apply to *C. coriaceum*. Its leaflets are distinctly stalked, and it may pass as membranaceous when compared with the Bornean species, or with ferns in general. There is an element of red in the color of its stipe, less marked than in *C. schlechteri;* but this does not show at all, or is rather replaced by yellow, in the stipes of *C. grande* and *C. magnificum*. The latter is membranaceous in a degree I have never before seen approached in any fern with such ample lamina; when it is held against a printed page and before a light, one can read through it with ease.

The five species of *Craspedodictyum* now known may be distinguished thus:

1. Lateral pinnæ stalked.
   2. Intermediate leaflets much smaller than the medial.... 1. *C. quinatum.*
   2. Intermediate leaflets moderately smaller than the medial. 2. *C. schlechteri.*
1. Lateral leaflets decurrent to stipe.
   2. Coriaceous.......... 3. *C. coriaceum.*
   2. Thin.
      3. Ternate.......... 4. *C. grande.*
      3. Quinate.......... 5. *C. magnificum.*

DORYOPTERIS CUSPIDATA Copeland, sp. nov. Plate 4.

Stipitibus confertis, gracilibus, usque ad 12 cm longis, atrocastaneis nitidis, deorsum paleis parvis atrocastaneis caducis ornatis, sursum angustissime alatis; fronde deltoidea, ca. 5 cm alta et lata, trifoliolata, glabra, coriacea, more D. concoloris ad basin tripinnatifida, qua specie lobis angustioribus conspicue cuspidatis et linea sorifera extus insigne nigra differt.

MINDANAO, Santa Maria, *Bur. Sci. 16515 Reillo,* 1912.

Distinguished from the Luzon plant called *D. concolor* by the more evident wing on the rachis, rather smaller and distinctly thicker frond, with narrower, conspicuously cuspidate lobes, relatively wider inflexed margin, and the black line, conspicuous from above after the protective margin expands.

The apical point, which distinguishes this plant conspicuously from the commoner Luzon species, can be matched in some American specimens; the latter, as represented here, are thinner, with less evidently winged stipe, and without the black line marking the sorus. It may be expedient to continue to construe *D. concolor* as a plant of exceedingly wide distribution; thus emphasizing the fact, equally true whether we recognize one species or a number of very similar species, that such a distribution has been reached and is maintained. The not very remotely related ferns *Hypolepis punctata, Histiopteris incisa,* and *Pteridium aquilinum* illustrate the same fact and raise the same problem; but any convenience gained by recognizing a single species as exceedingly wide-spread is more than offset, if this course keeps us from recognizing its distinct local derivatives. The African *Cheilanthes kirkii* would better be treated as a distinct species, of *Doryopteris.*

DORYOPTERIS BRANNERI Copeland, sp. nov. Plate 4.

Stipitibus confertis, ebeneis, teretibus, nudis, frondis sterilis 6 cm alta, gracile, fertilis 25 cm alta, valida; fronde sterile 6 cm longa, 4 cm lata, haud profunde lobata lobis deltoideis, obtusis, 10–15 mm latis, venis anastomosantibus; fronde fertile ca. 15 cm longa et lata, coriacea, glabra, brunnea, trifida et ad basin basiscopice tripinnatifida, segmentis basalibus deorsum basiscopice valde acutis; segmentis cujusdam ordinis similibus, linearibus, apud baseos 5–7 mm latis, apices acuminatis versus sensim angustatis, rectis vel sinuatis, valde remotis sed ala aequale media latetudine laciniarum ubique connexis.

Brazil, *J. C. Branner,* 1874.

In the polymorphic group of *D. lobata,* this most resembles *D. acutiloba* Prantl as to the fertile frond, but the sterile one

is essentially different. The narrow, remote divisions mark it off clearly from other species. It is more than thirty-five years since I marked this specimen as probably new; as it seems still to be undescribed, I take the opportunity to dedicate it to the memory of the eminent geologist who collected it.

THE IMAGINARY GENUS CAMPYLOGRAMMA

The first word on this "genus" is its original publication, as follows:[10]

Campylogramma, v. A. v. R.

Hemigrammae affinis sed frondibus fertilibus non vel vix contractis, costulis (main veins) munitis, areolis venulis liberis Aspidii more, soris rotundatis ad linearibus, in diversas partes patentibus.

By the shape of the sori intermediate between Dictyopteris and Dictyocline.

Campylogramma lancifolia, v. A. v. R., tab. I.

Rhizoma repens, intricatum, in sicco nigrum, squamulis deciduis, fuscis, lanceolatis, fragilibus vestitum. Stipites plus minusve sparsi, alati, 10–45 cm. longi, frondium fertilium quam sterilium multo longiores, glabri, parte exalata 5–30 cm. longa, ala anguste lineari-cuneata, in fronde sensim transienti. Frondes tenuiter coriaceae, glabrae, lanceolatae, acute vel obtuse acuminatae, subintegerrimae ad irregulariter subsinuatae; frondes steriles ± 25–30 cm. longae et 4–6 cm. late, costa costulisque prominentibus, costulis patentibus, rectis vel leviter flexuosis, marginem non attingentibus, inferioribus sensim irregularibus et in ala deficientibus; frondes fertiles paullo minores. Sori compitales vel ad venulas liberas positi, subrotundi ad breviter lineares, receptaculis brevioribus rectis vel subrectis, longioribus rectis, curvatis, subcircularibus, sigmoideis ad irregulariter flexuosis vel ramosis, irregulariter sparsi vel seriati et series sororum costa vel margine plerumque paralleles vel subparalleles.

The description is taken from a living specimen cultivated in the Buitenzorg Gardens.

Celebes (*Mt. Boesoe*), Capt. van Vuuren's Exploration Expedition, coll. Rachmat No. 165.

The last word I have seen was published less than two years later, as follows:[11]

Campylogramma lancifolia, v. A. v. R., Bull. Buitz. 1916, XXIII, 7, tab. I; Mal. Ferns & All., Supplem. I, 334.

Since the plants cultivated in the Buitenzorg Gardens, on which the description of this species is based, have become older, it proves that the stipes are articulated to the rhizome, a fact not to be seen in young plants even when dried. It is therefore rather evident that the genus Campylogramma (as far as regards this species, the rhizome and base of the stipes of C. pteridiformis v. A. v. R. being still unknown) is related to the genus Pleopeltis § Pleuridium and this species to Pl. Zollingeriana v. A. v. R. (=*Polypodium heterocarpum Bl.*, Flor. Jav., II, 167, tab. LXXV).

[10] Bull. Jard. Bot. Buit. II, No. 23 (1916 [?]) 7.
[11] Ibid. No. 28 (1918) 11.

I am unable to examine which of both species may probably have been the ancestor or descendant of the other or that they are both descendants of a common ancestor. While the knowledge of the often easily recognizable affinity between genera and species is very valuable for their systematical grouping, I think the tracking of their probable or apodictically pretended descent, which depends as a rule only on not to be proved suppositions or personal conceptions, is too trifling and the mention of it too worthless to take into consideration for systematical-botanical publications.

If its author had seen fit to withdraw his genus when he found that he had described it under a delusion, his closing remarks could well be ignored; but, since the genus is left standing until somebody else expunges it, the appropriateness of these words can hardly be overlooked.

In the generic diagnosis, "Hemigrammae affinis" is the major element. A genus must be placed somewhere; and, when the formal diagnosis is incomplete, the location of the genus supplies the deficiencies; for illustration, in this instance, it tells us that there is no indusium. The "easily recognizable affinity" is more than merely valuable; in my own repeatedly expressed judgment, it is the sole basis on which, as our knowledge becomes complete, genera can properly be recognized and defined. The easy recognition of affinity to *Hemigramma*, on the part of a fern with "rhizoma repens, intricatum," etc., was a mental achievement which ought not to have been disturbed by the subsequent discovery of articulate stipes. The keen botanist who separated *Hemigramma* from *Leptochilus* ignored any trace of articulation of the latter.

If *Campylogramma* had been a real relative of *Hemigramma*, but descent was an inscrutable mystery, one wonders why it might not have been a *Tectaria*, or, if not that, *Heterogonium*. If descent could be ignored, it would probably never be necessary to describe another genus of ferns. There are a considerable number of *Tectaria* species with sori of irregular shape. For example, to quote authority which the author of *Campylogramma* will hardly impeach; "D(ictyopteris) heterosora, Bedd. . . . Sory very abundant small, irregular, often confluent." [12] Unless it be the imaginary affinity to *Hemigramma*, which would not serve the purpose, there is absolutely nothing in the diagnosis of the genus *Campylogramma* to distinguish it from Beddome's fern.

However, since the author of the genus has relocated it, we can substitute *Pleopeltis* for *Hemigramma*. If we then abstain from

[12] Malayan Ferns 518.

the technicality that real *Pleopeltis* is unknown in Malaya, and agree that "the genus Campylogramma . . . is related to the genus Pleopeltis," etc., we will next be driven to wonder wherein this affinity falls short of identity. *Polypodium heterocarpum* Blume possesses in their entirety the characteristics by which *Campylogramma* was distinguished from *Hemigramma,* and was named to mark the character apparently most essential for the recognition of the "new" genus. In rhizome, paleæ, stipe, size, form, margin, texture and surface of frond, venation and fructification, *C. lancifolia* is described as identically like *P. heterocarpum,* which was long since reported from Celebes. Not to mention generic distinctness, we are not shown that it is specifically different.

Incidentally, "Pleopeltis Zollingeriana" with the entailed initials is a pure incumbrance of synonymy. There are rules, though I do not follow them, under which this fern should be called *Polypodium zollingerianum,* but there never was a rule which would justify that name in *Pleopeltis.* If it were a *Pleopeltis,* which it is not, its name would be *Pl. heterocarpa* (Blume) Moore.

As to the validity of *Campylogramma,* the status of *C. pteridiformis* v. A. v. R. is absolutely irrelevant. The genus falls with its type species. I do not suspect *C. pteridiformis* and *C. lancifolia* of being congeneric, but *Campylogramma* cannot be salvaged for application to a species that, if specifically valid, was unknown when the genus was described.

Apodictic is a very fine word. Introduced where it is, in discussing a genus originally defined as "Hemigrammae affinis," it can hardly have been aimed elsewhere than at my positive derivation of *Hemigramma* from *Tectaria*—as to which, I will accept the expression cheerfully. The recognition of affinity is conceded to be easy, so I will not waste space rehearsing the proof that *Tectaria* and *Hemigramma* are related. Of the two, *Tectaria* is more than pantropic in distribution, rich in species and with recognizable groups of species, with recognized genera derived from it, and on the other hand with "easily recognizable affinity" to a probably still older and greater genus, *Dryopteris. Hemigramma* is comparatively local, probably reaching out from Malaya only as far as New Guinea and Formosa, comparatively homogeneous, without recognized relatives other than *Tectaria,* still plastic and apparently subject to reversion to a tectarioid aspect. Most botanists will agree, on such evidence, that *Tectaria* is the older group. If there is still some mystery as to

whether the older or the younger group is the probable parent, that problem may be left for future elucidation. The dictionary says that "Apodictic or Demonstrative Judgments are subjectively and objectively sure; sure to him who holds them, and capable of being enforced upon all of sane mind."

EGENOLFIA FLUVIATILIS Copeland, sp. nov. Plate 5.

Rhizomate ad saxa in rivulis repente, 2 mm crasso, paleis fuscis lanceolatis ad et prope apicem vestito; stipitibus approximatis, frondium sterilium 5–10 cm, fertilium 12–20 cm altis, rhachibusque sordide viridibus paleis fusco-castaneis lanceolatis 2 mm longis ornatis; fronde sterile lanceolata, ca. 15 cm longa, 4–5 cm lata, pinnata, rhachi ala angustissima pinnis interrupta ornata, apice prolifera; pinnis erecto-patentibus, stipitulatis, acutis, basibus cuneatis, praecipue margine acroscopico argute grosse serratis, glabris, herbaceis, plumbeo-viridibus; venis plerisque bis furcatis, ramo mediale in dentem et distale in spinam deciduam protensis, pinnis medialibus 3 cm longis, 5 mm latis, apicem et basin frondis versus minoribus; fronde fertile usque ad 15 cm longa, 2 cm lata, pinnis oblongis, crassis, siccitate evolutis.

LUZON, Isabela Province, San Mariano, altitude 700 m. s. m., *Bur. Sci. 46986 Ramos and Edaño*, 1926.

The position, shape, and color of the sterile pinnæ distinguish this sharply from the common *E. appendiculata*. It is equally distinct from all of the species described by Fée and ignored by later writers; some of these, at least, are distinct and easily recognizable. The remarks made under *Athyrium altum* are even more applicable here.

POLYPODIUM DEORSIPINNATUM Copeland, sp. nov.

Goniophlebium Eupolypodio affine, rhizomate repente, 1–2 mm crasso, paleis castaneis sparse denticulatis lanceolatis acuminatis 2 mm longis radibusque dense vestito; stipitibus remotis, 10 cm altis, stramineis, glabris; fronde usque al 30 cm alta et 9 cm lata, deorsum pinnata, sursum fere ad rachin pinnatifida; pinnis et segmentis frondis adnatis, 7 mm latis, fere horizontalibus, obtusis, praecipue sursum argute haud profunde serratis, papyraceis, omnino glabris; venis aut anastomosantibus et seriem unam areolarum includentibus aut liberis et triramosis; soris orbicularibus vel sub-oblongis, superficialibus.

FORMOSA, Mount Arisan, altitude 2,500 m. s. m., in rupibus, *Faurie 581*, June, 1914.

More like *P. nipponicum* than the other related species, but conspicuously different in being naked. It stands to *P. vulgare* in much the same relation as does *P. californicum*.

POLYPODIUM BONGOENSE Copeland, nom. nov.

Polypodium brooksii COPELAND, Philip. Journ. Sci. § C 12 (1917) 60, non C. Christensen, Index Suppl. (1913) 4 or 58.

LOXOGRAMME PARALLELA Copeland, sp. nov.

As originally described, this was a very small fern; and, in treating the genus,[13] I distinguished it from *L. linearis* in the key to the species, by its having fronds under 20 centimeters long. We have very many collections of it from the Benguet region, in just one of which the largest fronds reach a length of 22 centimeters. Their usual length is 15 centimeters or less. A fern found on Mount Kinabalu, which I have regarded as this species, is moderately larger.

I have now from Mount Matutum, in Mindanao, a fern otherwise very similar, but with fronds reaching a length of even 50 centimeters, and therewith a width of about 15 millimeters, rarely more. In this collection, few plants fail to have some fronds over 25 centimeters long. In the absence of other evident good distinctions, I am letting this pass for the present as *L. parallela.* Further collection should show whether or not the gap in stature is constant. This large plant is not *L. linearis,* a Formosan species, distinguished by size in the key referred to (loc. cit. p. 44). The sori of the latter overlap, but those of this large *L. parallela* are strictly seriate.

LOXOGRAMME SCOLOPENDRINA (Bory) Presl.

Loxogramme scolopendrina (Bory) PRESL, Tent. Pterid. 215.

Antrophyum involutum BLUME, Fl. Javae (1828) pl. 37. fig. 1, excl. syn.

Grammitis scolopendrina BORY, Voy. Coquille (1829) 257, pl. 30, fig. 1.

Selliguea flavescens J. SMITH, Journ. of Bot. 3 (1841) 399, excl. syn.

Bory's plant and Blume's seem to be absolutely identical. In distinguishing his *Antrophyum coriaceum* and *A. avenium* (both first as *Grammitis*), Blume particularly emphasized the carinate character of the costa of his *A. involutum,* the others having it flattened beneath and prominent above. This is a distinguishing characteristic of the species, which ranges throughout the Malay region and for some distance onto the continent. Bory's specimen was accredited to New Zealand, but this origin is doubted.

LOXOGRAMME AVENIA (Blume) Presl.

Loxogramme avenia (Blume) PRESL, Tent. Pterid. 215.

This name has priority over *L. blumeana* Presl, the plants being regarded as identical.

[13] Philip. Journ. Sci. § C 11 (1916) 43.

LOXOGRAMME INVOLUTA (Don) Presl.

Loxogramme involuta (Don) Presl, Tent. Pterid. 215.
Grammitis involuta DON, Prod. Fl. Nepal. (1825) 14; HOOKER and GREVILLE, Icones Fil. (1828) Pl. 53.
Grammitis flavescens Wallich, nomen.

All of our specimens from northern India, including authentic *G. flavescens*, are alike in having the costa prominent, but not carinate even at the base. I have tried unsuccessfully to locate a type specimen of Don's fern, collected by Hamilton, but am glad to acknowledge the assistance of Mr. William Smith, regius keeper of the Royal Botanic Garden, Edinburgh, where I thought such a type might exist. The plants of northern India differ again from those of Malaya in commonly having much longer sori. I doubt that the two species meet. My only Yunnan specimen, *Henry 9059c*, received as *Gymnog. involuta*, is referable to neither of them; it may be *L. fauriei*, which seems to be common in some parts of China.

CALYMMODON ASIATICUS Copeland, sp. nov.

Caudice 0.5 mm crasso, breve, radicibus et axibus frondium emortuarum incrassato, apice paleis ferrugineis ca. 1 mm longis lanceolato-ovatis vestito; stipitibus caespitosis, 1–3 mm longis; fronde plerumque 3–4 cm longa, 5 mm lata, ad alam angustissimam costae ad stipitem etiam decurrentem pinnatifida, praecipue ad costam pilis pallide fulvis 0.4 mm longis deciduis ornata; segmentis sterilibus patentibus, frondium majorum 3–3.5 mm longis, ca. 0.8 mm latis, apice rotundatis, paucis et sese remotis, infimis aut aequalibus aut paullo brevioribus et acutioribus nullibi valde diminutis; segmentis fertilibus vix 2 mm longis, conduplicatis 1 mm latis subacutis, explanatis quam latis latioribus, supremis latissime adnatis, aliis costam frondis versus modo contractis et angustius adnatis; soro elongato.

Annam, Mount Bana, *J. and M. S. Clemens 3800*, on bowlders in shaded ravines, May–July, 1927.

Nearest to *C. ordinatus* Copeland, Philip. Journ. Sci. 34 (1927) 267, but smaller, with smaller paleæ, the sterile segments slenderer and decidedly more remote, and without the characteristic long sequence of uniform fertile segments. The collection is of not less than one hundred very uniform plants.

ILLUSTRATIONS

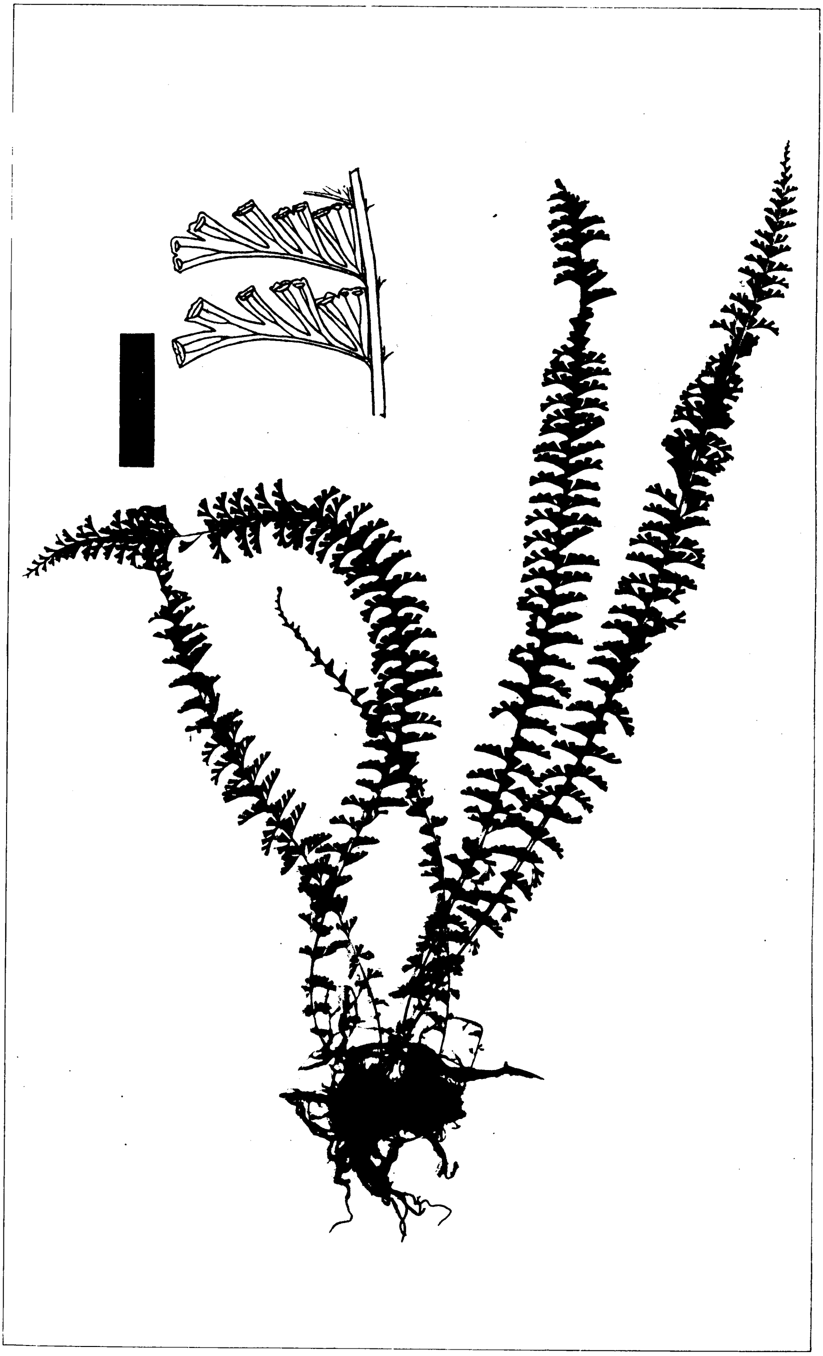

PLATE 1. LINDSAYA FISSA COPELAND, SP. NOV.; TYPE.

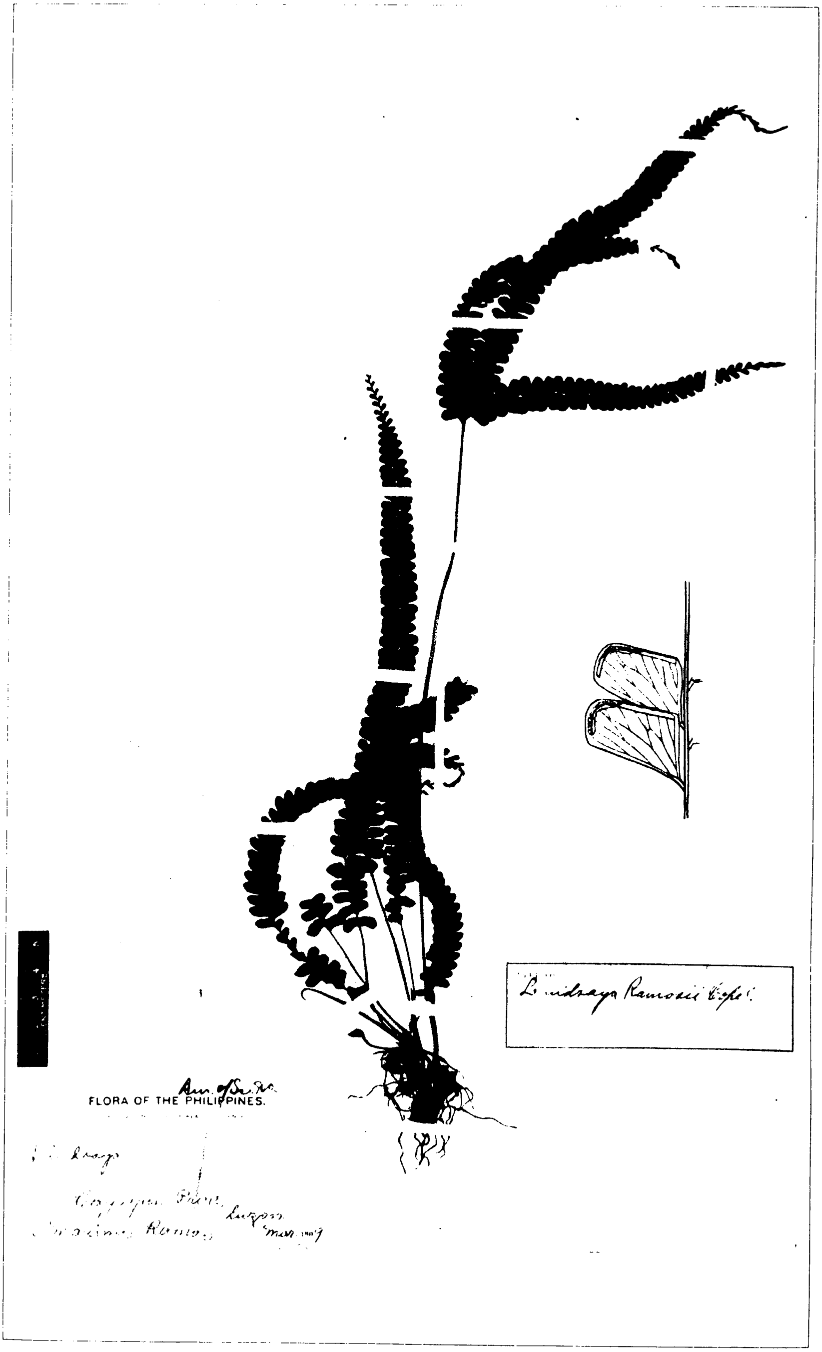

PLATE 2. LINDSAYA RAMOSII COPELAND, SP. NOV.; TYPE.

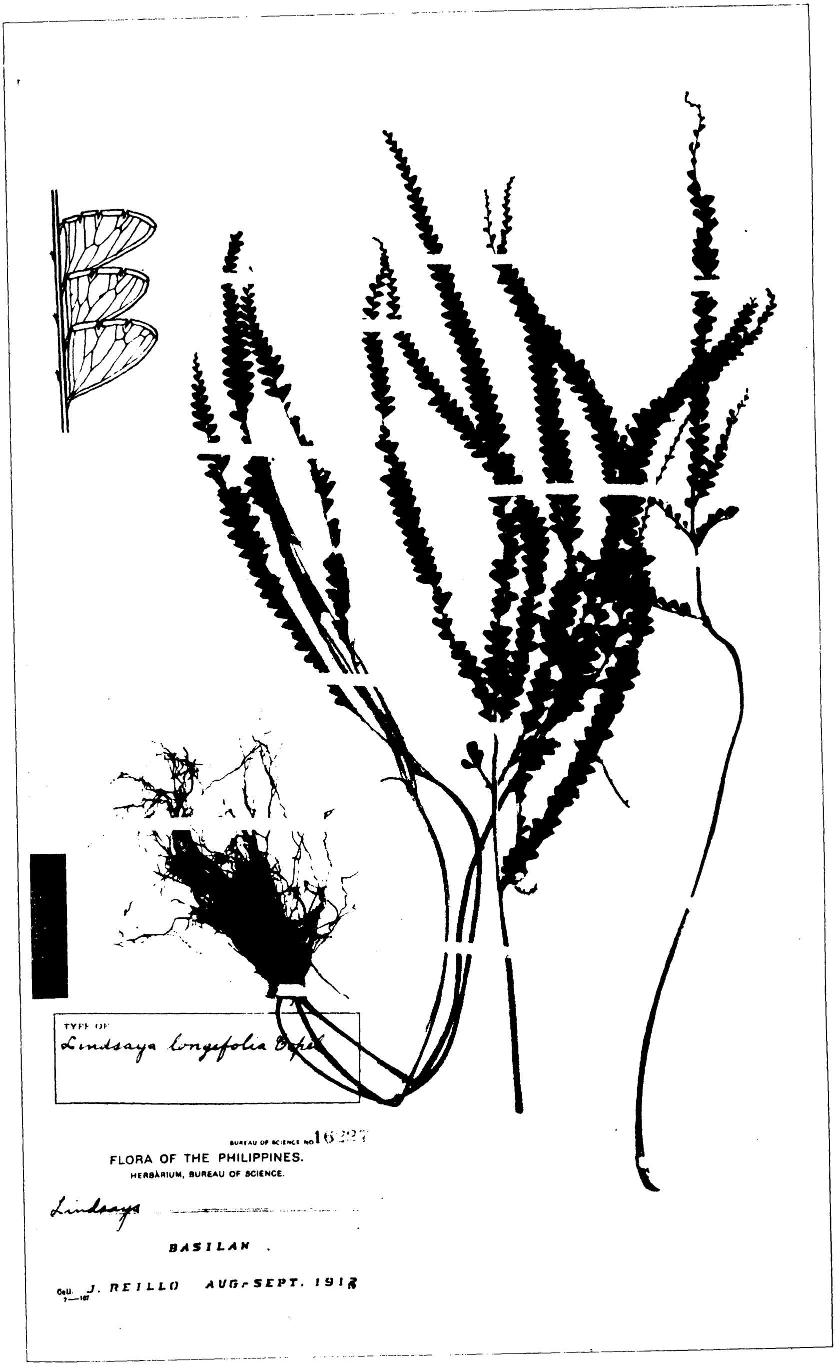

PLATE 3. LINDSAYA LONGIFOLIA COPELAND, SP. NOV.; TYPE.

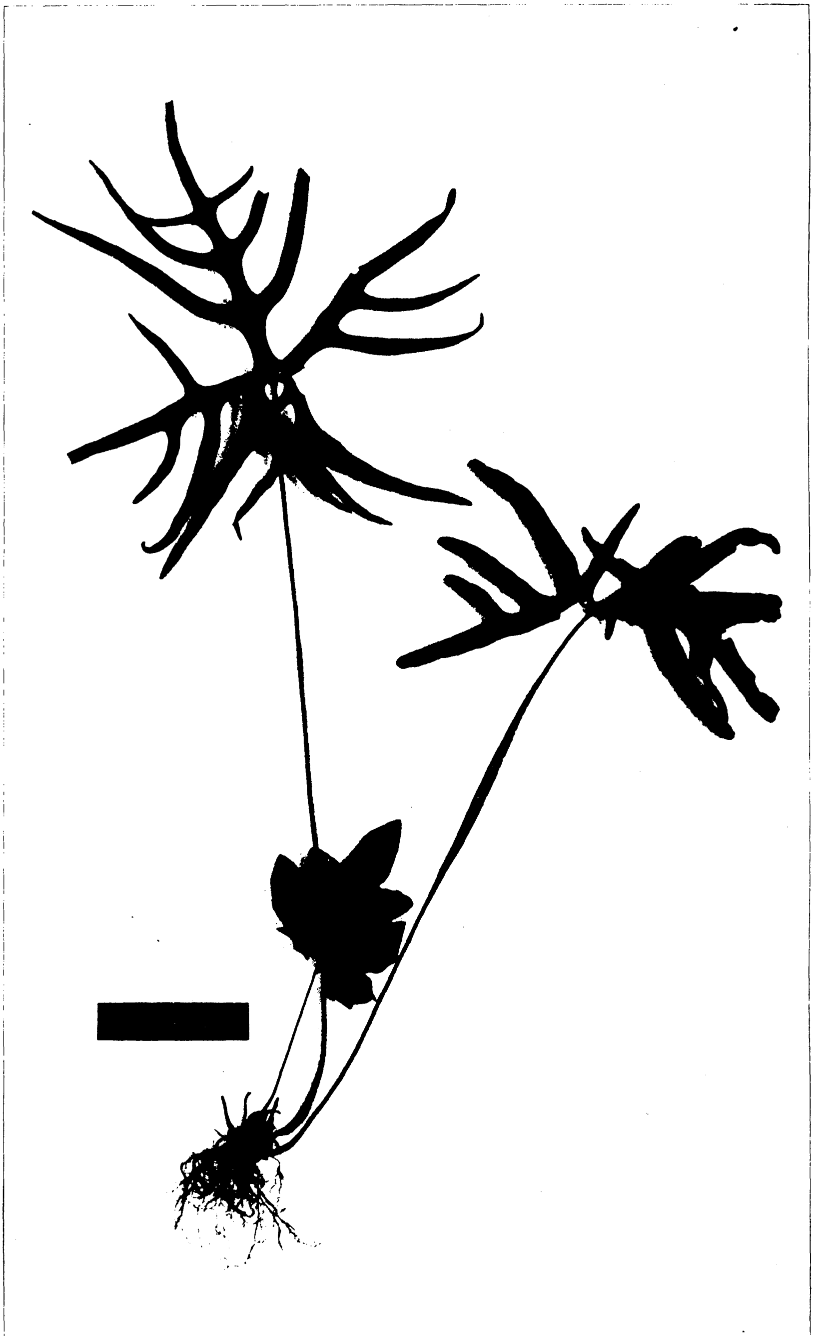

PLATE 4. DORYOPTERIS BRANNERI COPELAND, SP. NOV.; TYPE.

PLATE 5. EGENOLFIA FLUVIATILIS COPELAND, SP. NOV.; PART OF TYPE COLLECTION.

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THE PHILIPPINE JOURNAL OF SCIENCE

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TIPULOIDEA OF THE TONGARIRO NATIONAL PARK AND OHAKUNE DISTRICT, NEW ZEALAND (DIPTERA)

By CHARLES P. ALEXANDER

Of the Department of Entomology, Massachusetts Agricultural College Amherst

ONE TEXT FIGURE

INTRODUCTION

The detailed knowledge of the crane flies of the immediate vicinity of Ohakune and Mount Ruapehu, Wellington Province, New Zealand, that has now become available through the untiring efforts of Mr. Thomas R. Harris and a few other collectors, well warrants the publication of a list of the species.

The first specimens that were received from the vicinity of Ruapehu were collected by Mr. Morris N. Watt in January, 1921, along the trail to the mountain hut on the southwest side of the mountain. The flies were taken in the zone of silver beech (*Nothofagus menziesii* Hooker f.) and included the following species: *Macromastix ferruginosa ruapehuensis, Discobola tesselata, Zelandomyia raupehuensis, Z. watti, Gynoplistia (Cerozodia) hudsoni hemiptera, Ceratocheilus ochraceum,* and *Molophilus latipennis.* All of the species described by the writer were based either wholly or in part on Mr. Watt's material. In late December, 1921, and early January, 1922, Mr. Watt and Mr. Cuthbert C. Fenwick again visited Ruapehu, this time on the northern side, and collections were made in the vicinity of their camp at an approximate altitude of 3,700 feet, where the beech forest, tussock land, and alpine scoria begin to intermingle with one another. The Tipulidæ collected at this time included the following undescribed forms: *Molophilus flagellifer, M. niveicinctus,* and *Amphineurus gracilisentis,* as well as sev-

eral species that had been previously described and are recorded later in the present paper. The various excursions undertaken by Harris to the camp on Ruapehu are discussed under the second part of this paper. The few crane flies that were taken in this region by Hudson in 1912 were listed the following year.[1] Hudson's second trip to Ruapehu, in company with his daughter, Miss Stella Hudson, in 1922, included a few additional novelties that were taken in the vicinity of the Whakapapa camp on the northern side of Ruapehu at an approximate altitude of 3,700 feet, and have been described by Edwards; these are *Macromastix bivittata, M. elongata,* and *Gynoplistia* (*Gynoplistia*) *orophila.*

The first Harris collections that were received by the writer were kindly sent by Dr. James W. Campbell, and included only a few miscellaneous species that had been taken by Harris in the vicinity of Ohakune in 1919 and 1920. Strange to say, these desultory collections included a few species, chiefly of the genus *Gynoplistia,* that were not rediscovered during the subsequent systematic combing of the region by Mr. Harris, beginning in the early spring of 1921 and continued until 1926. These various Harris collections, made in the near vicinity of Ohakune and in Tongariro Park on Mount Ruapehu constitute the basis for the present list. A simple expression of thanks for the untiring efforts of Mr. Harris in making known the fascinating tipulid fauna of New Zealand seems but inadequate reward for the long hours spent afield and at home preparing the material. The writer can honestly state that never has he enjoyed such capable coöperation in the development of a local faunal list and such intelligent appreciation of the problems to be met as has come from Mr. Harris, to whom all credit is given for the results obtained during this study. This abundant material has rendered the writer's task a comparatively easy one.

GEOGRAPHICAL LIMITS ADOPTED IN THE PRESENT REPORT

Mr. Harris has suggested the following geographical limits, which are herein adopted: "I would reckon the Ohakune district to extend from Waimarino, 18 miles to the north (of Ohakune), to Waiouru, 17 miles to the south, and back to Mount Ruapehu. You then have a natural boundary of tussocks and plain on both sides." (See fig. 1.) Acting upon this suggestion, the writer has adopted a circular area having an

[1] Trans. N. Z. Inst. 45 (1913) 57-67.

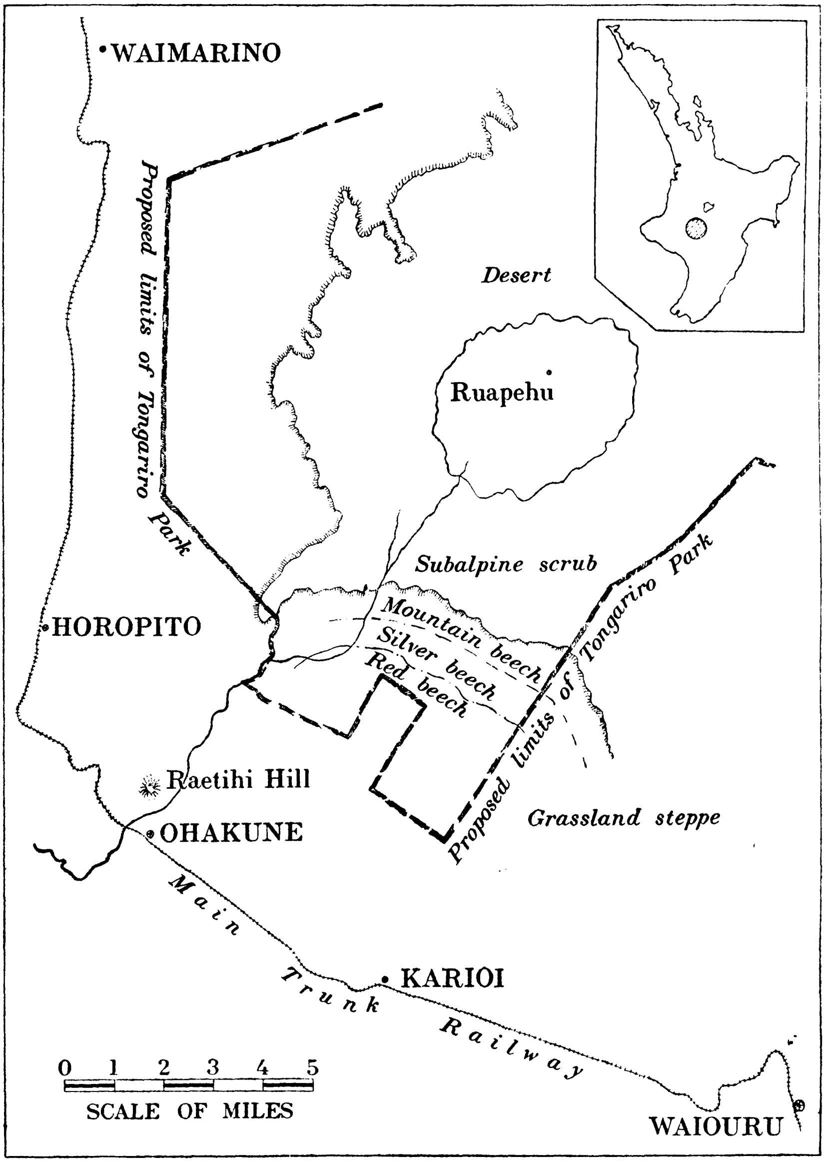

FIG. 1. Ohakune district and Toongariro Park, North Island, New Zealand. The location and the area of the park are indicated by the shaded circle in the index map.

18-mile radius from Ohakune as a center, thus including approximately 1,000 square miles, although the actual area upon which collections have been made presumably would not include

a tenth of that amount. As might be expected, the principal collections have been made while on short trips away from home in the immediate vicinity of Ohakune. Other collections have been made along Mangawhero River, along the slopes and on the summit of Raetihi Hill, and at various stations along the Main Trunk Railway from Waimarino to Waiouru, chiefly at Horopito and Karioi. The average altitude at which the Ohakune collections were made has been given as 2,060 feet, furnishing a good basis for comparison with the rather numerous specimens from the slopes of Mount Ruapehu at altitudes between 3,000 and 4,500 feet.

PHYSICAL GEOGRAPHY, CLIMATE, AND VEGETATION

Mr. Randal Mundy, botanist, resident of Ohakune for several years, has very kindly supplied me with instructive data regarding the physical features of the country, the rainfall, insolation, and other information. These data are given herewith in order that the conditions under which this abundant and remarkable crane-fly fauna exists may be fully appreciated.

Character of country.—The cone of Ruapehu consists of volcanic rocks, andesitic lava, scoria, lapilli, etc., which, on the lower slopes, have been greatly disintegrated so that at the base of the mountain the surface cover shows an outer thin layer of scoria and lapilli overlying a sand layer, and below this a clayey sand with included rock fragments.

In the area covered by the mixed rain forest, the ground shows a rich, loose, blackish brown humus soil, 1 to 2 feet thick, overlying a stratum of reddish brown sandy clay, 1 to 2 feet thick, which again rests upon 3 to 4 feet of stiff buff clay which often lies on a bluish white calcareous mud rock known as "papa-rock." Thus in the forest region, below the depth of 3 to 4 feet, there is a stiff subsoil forming a hardpan into which the tree roots have a hard task to penetrate. Hence the big trees have no taproots but many wide-spreading superficial roots, and as a consequence are readily overthrown by strong winds or earthquake shocks. This statement is supported by the fact that the bush floor is everywhere littered by great fallen trunks showing all stages of decay and making progress through the forest an arduous task.

Rainfall.—Twenty-five years ago (about 1904) all the land around Ohakune was densely forested and had an annual rainfall of nearly 100 inches in the neighborhood of the numerous hill ridges. North of Ohakune for a distance of 9 miles, the

virgin forest is still intact save for the depredations of wandering cattle, and this hummocky bushed area probably has a rainfall of 80 inches or more annually, the rain being fairly equally distributed throughout the year. In the cleared areas the rainfall is much lower. The fall for the years 1919 to 1921 was as follows: 1919, 41.42 inches; 1920, 59.7 inches; 1921, 50.92 inches. This total of 152.04 inches gives an average of 50.7 inches annually for the open township free from bush.

Seasons.—The climate of the Ohakune Plateau is a mild temperate one. The four seasons are experienced here but are not so well-marked as in colder latitudes. Summer temperatures range from 70° to 80° F. or over; the heavy bush is cooler than the open. Spring and fall are mild and pleasant. Winter is never very severe, the mercury rarely falling below 20° F.; but, owing to the high elevation and frequent clear skies, keen night frosts occur in winter and, at times, in spring and fall. These hoar frosts are common in the open cleared land, early in the morning, with the formation of perpendicular ice prisms upon the ground surface. There are usually very few snowfalls about Ohakune. In 1920 there were but two snowfalls, one of 4 or 5 inches, the other of about 2 inches, which were soon melted by the sun. In 1921 there was a single snowfall of about 2 inches. Harris kept a detailed weather report from May, 1922, to May, 1923, and this indicates frosty days from April through September. This fact and the account of winter conditions in the bush, discussed below, becomes of great value in a consideration of the winter crane flies discussed under a later caption.

Winds.—The prevailing wind is from the west or northwest and it brings heavy rain. South winds bring cold. Easterly (east and northeast) winds bring clear skies and fine, dry days.

Insolation.—At the elevation of Ohakune, the heating power of the sun's rays is very great, even in winter, but after sunset there is a sudden drop in the temperature. The proportion of sunny days is high. In summer, daylight lasts from 4 a. m. to 8.30 p. m. In winter it lasts from about 6.30 a. m. to 5 p. m.

Winter conditions in the bush.—In the tall, thick rain forest, owing to the close, overhead foliage cover of the great taxad trees, extremes of temperature are not felt, and throughout the year the forest temperature is fairly equable. In the coldest part of winter, when all the cleared land may be enduring hard frosts, the forest interior has the appearance of a vast conservatory stocked with healthy green vegetation and with no sign

of frost except where, owing to a fall of trees, the bush floor lies open to the sky. In the bush, too, there is no general leaf fall at the cold season of the year, the trees, shrubs, and herbs (with the exception of the fuchsias and ground orchids) retaining their foliage throughout the winter and shedding it almost imperceptibly long after the following spring has clothed them with foliage. Thus, even in the coldest weather, in the shelter of the bush, the lower forms of animal life are not subjected to very rigorous conditions.

Vegetation.—It is well-known that crane flies are lovers of rich vegetation, usually near running or standing water. Definite groups or associations of crane-fly species are found to frequent equally definite plant societies or associations, and this interrelationship is often well marked. No serious attempt can be made to correlate insect societies without a careful study of the plant associations, and for this reason, a general account of the vegetation of the places where the Harris collections were made is given. The notes are based on extensive data sent me by Mr. Randal Mundy, to whom my sincere thanks are extended. For more-detailed accounts of the plant ecology, the student is referred to three recent and comprehensive reports.[2]

The lower levels of the Ohakune section, at altitudes ranging from 2,000 to 3,000 feet, support a dense, lofty, evergreen, mixed rain forest that almost rivals a semitropical forest in its luxuriance. Above the 3,000-foot contour, however, the character of the forest changes, the mixed forest giving way to the beech forest which extends to the mountain hut on the base of Ruapehu (4,550 feet).

The mixed rain forest.—Seen from the open at a distance of half a mile, the rain forest shows a fairly even contour line about 80 to 90 feet above the ground and stands out as a rather somber, sepia-tinted mass of foliage. Seen closer, the forest has a dark yellow-green color, caused by the dominance of the great taxad trees—rimu (*Dacrydium cupressinum*), matal (*Podocarpus spicatus*), miro (*P. ferrugineus*), kahikatea (*P. dacrydioides*), and totara (*P. totara*)—which reach an average height of 80 to 90 feet, though individual trees may be more than 100 feet in height. These characteristic trees grow intermixed and make up the great bulk of the forest, forming the sheltering

[2] Cockayne, L., Vegetation of New Zealand (1921) 1–364 and Report on a Botanical Survey of the Tongariro National Park (1908) 1–42.—Kensington, W. C., Forestry in New Zealand (1909) 1–118.

top cover. All other tree species are merely secondary in the composition of the forest and have to fit themselves in as best they can among the big conifers.

On entering the shady, humid "bush" one is bewildered by its dense lush greenery which shuts out all view beyond a distance of 20 to 30 yards. One notes that the tree heads are arranged approximately in three tiers of foliage. The first, or upper, tier is formed by the tall conifers, as given above; the second tier consists of the heads of trees 40 to 60 feet high; for example, hinau, pokaka, black maire, *Weinmannia racemosa*, tawa, and *Griselinea littoralis;* the third tier, averaging from 20 to 30 feet in height, usually shows intermixed *Melicytus ramiflorus, Carpodetus serratus, Pittosporum colensoi, Aristotelia racemosa, Fuchsia excorticata, Nothopanax arboreum, N. colensoi, N. edgerleyi, Schefflera digitata, Pseudopanax crassifolium, Myrine salicina,* and *Pennantia corymbosa.*

Below these three tiers of trees occur several species of shrubs, varying in height from 5 to 15 feet, the commonest of which are *Drimys colorata, D. axillaris, Melicope simplex, Myrtus pedunculata, Nothopanax anomalum, Leucopogon fasciculatus, Suttonia divaricata, Coprosma grandifolia, C. robusta, C. tenuifolia, C. lucida, C. rotundifolia, C. rhamnoides, C. foetidissima, Brachyglottis, Paratrophis,* and *Alseuosmia macrophylla.* In addition, there is a plentiful sprinkling of handsome tree ferns, from 4 to 20 feet high, of the four species *Cyathea dealbata, Dicksonia fibrosa, D. squarrosa,* and *Hemitelia smithii.*

The ground cover consists chiefly of big tufts of a coarse fern, *Lomaria discolor,* or, in very damp places, of dense tufts of harsh *Polystichum vestitum* ferns, along with many tufts of the beautiful single- or double-crape ferns, *Todea hymeno-phylloides* and *T. superba.* In better-illuminated areas the ground is covered with clumps of bush grass, and in the intervening spaces grow filmy ferns, mosses, and hosts of *Coprosma* seedlings. There are, in addition, many lianes and epiphytes, giving to the bush vegetation a somewhat tropical appearance.

The upper beech forest.—Four and one-half miles up the Ruapehu track, at an elevation of about 2,900 feet, the large trees of the mixed forest gradually disappear, giving way to an almost pure beech forest, which extends for another four and one-half miles to the mountain hut at an altitude of 4,550 feet on the lower slopes of Ruapehu. This beech forest is composed of four species which follow one another, in a rather indefinite

zonal arrangement, as one approaches the mountain. Thus, where the mixed forest reaches its upper limit, big trees of *Nothofagus solandri* become common and these are succeeded in turn by belts of *N. fusca, N. menziesii,* and *N. cliffortioides,* the last species reaching, with gradually dwindling height, to the mountain hut. At about 3,000 feet *Libocedrus bidwillii* puts in an appearance, and is scattered throughout the beech zones up to the 4,500-foot level. At the 3,100-foot contour nearly all of the tree and shrub species of the lower mixed forest have disappeared and a new assemblage of small trees and shrubs appears among the beeches; thus we find as characteristic species an abundance of *Nothopanax colensoi, Phyllocladus alpinus, Coprosma cuneata, Dacrydium biforme, D. bidwillii, D. colensoi, D. intermedium, Nothopanax simplex, N. parvum, Coprosma foetidissima, Griselinia littoralis,* and the big tufted sedge *Gahnia pauciflora.*

The trail to the mountain hut extends from Ohakune station through the three beech zones and subalpine conditions to the hut itself. The vegetation in the vicinity of the hut consists of shrubby mountain beech (*N. cliffortioides*), certain Epacridaceæ (*Dracophyllum* spp.), and grasses. The details of the subalpine Tipulidæ are given in the following section.

Mr. Mundy writes that Harris gathers most of his material by sweeping with his net the low underscrub of the forest, this including the various *Coprosma* species, *Leucopogan fasciculatus,* the ferns, *Lomaria discolor* and *Polystichum vestitum,* crape ferns, *Melicytus ramiflorus, Nothopanax, Drimys,* and bush grass.

SEASONAL DISTRIBUTION

Nothing has been recorded concerning the seasonal appearance of crane flies in any country in the Southern Hemisphere, and consequently the following data that have been derived from the present study are of especial value. As a basis for comparison, available records for the mountain hut and beech zones on Ruapehu, the higher slopes and summit of Raetihi Hill, and the red beech forest at Karioi are given. A special caption on Winter Tipuloidea is supplied.

MOUNT RUAPEHU

Ruapehu is an old volcano, supposed to be extinct, but still showing some thermal activity in the form of a hot lake at the bottom of its old crater. It is 9,175 feet above sea level, or approximately 7,000 feet higher than the Ohakune Plateau.

There are a few glaciers and snow upon the upper 2,000 feet of the summit region all the year round, but in winter the snow line descends to about the 5,000-foot contour line. The lower slopes of Ruapehu are deeply gullied, and from the radiating gullies many small rivers pour down. One of these, the Mangawhero, flows through Ohakune.

In order to compare the lower altitudes and rain-forest conditions obtaining near Ohakune, the material taken in the near vicinity of the mountain hut (4,550 feet) and along the trail to the hut (3,000 to 4,000 feet) by Harris and Watt is summarized. The latter collections are especially valuable as including the zones of red beech (*Nothofagus fusca*), silver beech (*N. menziesii*), and mountain beech (*N. cliffortioides*); the last as a narrow belt between 3,700 and 4,000 feet, but with stunted trees to the hut.

Harris made four trips to the mountain hut (February 25–28, 1922; January 12–15, 1923; January 4–6, 1924; January 20–21, 1924). It is rather unfortunate that no very fine weather was experienced by Harris on any of these trips, and the material that was taken was almost invariably the result of hurried collections between showers or at short intervals between violent wind storms.

January (midsummer) records from near the mountain hut (4,000 to 4,500 feet) in the zone of low scrub and grass steppe.

Dolichopeza atropos.
Macromastix ferruginosa ruapehuensis.
Macromastix fucata.
Limonia (Dicranomyia) annulifera.
Limonia (Dicranomyia) megastigmosa.
Limonia (Dicranomyia) sperata.
Limonia (Dicranomyia) weschei.
Discobola ampla.
Austrolimnophila argus.
Metalimnophila mirifica.
Zelandomyia penthoptera.
Zelandomyia ruapehuensis.
Zelandomyia watti.
Ischnothrix connexa.
Elephantomyia ruapehuensis.
Elephantomyia zealandica.
Aphrophila neozelandica.
Molophilus flagellifer.
Molophilus harrisianus.
Molophilus irregularis.
Molophilus latipennis.
Molophilus morosus.
Molophilus pulcherrimus.
Molophilus uniplagiatus.
Amphineurus (Amphineurus) lyriformis.
Amphineurus (Amphineurus) senex.
Amphineurus (Nesormosia) fatuus.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) harrisi.

The record of species taken along the trail, chiefly in the beech zones, is more extensive than the above, and is especially

valuable as a basis for comparison with the lower beech zones at Karioi, and the summit of Raetihi Hill.

January (midsummer) records along the track to the hut (3,000 to 4,000 feet), through the beech forests (Nothofagus spp., Libocedrus, and others).

Paracladura macrotrichiata.
Dolichopeza parvicauda.
Macromastix ferruginosa ruapehuensis.
Macromastix holochlora.
Macromastix viridis.
Macromastix lunata.
Limonia (Zelandoglochina) harrisi.
Limonia (Zelandoglochina) huttoni.
Limonia (Zelandoglochina) melanogramma.
Limonia (Dicranomyia) multispina.
Limonia (Dicranomyia) reversalis.
Limonia (Dicranomyia) seducta.
Discobola ampla.
Discobola tesselata.
Rhamphophila sinistra.
Austrolimnophila argus.
Austrolimnophila chrysorrhœa.
Austrolimnophila leucomelas.
Austrolimnophila marshalli.
Austrolimnophila nigrocincta.
Austrolimnophila oculata.
Austrolimnophila subinterventa.
Heterolimnophila truncata.
Metalimnophila mirifica.
Metalimnophila protea.
Zelandomyia ruapehuensis.
Zelandomyia watti.
Gynoplistia (Paralimnophila) skusei.
Gynoplistia (Gynoplistia) fimbriata.
Gynoplistia (Gynoplistia) lobulifera.
Gynoplistia (Gynoplistia) pleuralis.
Gynoplistia (Cerozodia) hudsoni hemiptera.
Atarba filicornis.
Elephantomyia ruapehuensis.
Elephantomyia zealandica.
Ceratocheilus ochaceum.
Aphrophila flavopygialis.
Molophilus bidens.
Molophilus flagellifer.
Molophilus irregularis.
Molophilus latipennis.
Molophilus oppositus.
Molophilus uniplagiatus.
Amphineurus (Amphineurus) hudsoni.
Amphineurus (Amphineurus) lyriformis.
Amphineurus (Amphineurus) senex.
Amphineurus (Nesormosia) fatuus.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) harrisi.
Amphineurus (Nothormosia) insulsus.

RAETIHI HILL

The following observations are by Mr. Randal Mundy:

This steep ridge, which forms a part of the southern boundary of the Tongariro National Park, lies close to Ohakune and rises to the height of 2,933 feet, or nearly 1,000 feet above the Ohakune Plateau. The rather extensive summit is fairly level and shows an almost vertical escarpment of friable limestone rock. Both the slopes and the summit are densely

timbered, bearing the trees and shrubs that are characteristic of the tall mixed forest at the 2,000-foot level. However, on the slopes, large contorted rata trees (*Metrosideros robusta*) appear in great numbers, intermixed with the big taxads, although they are almost absent from the forest at the base of the ridge; moreover, on the summit, many fine trees of *Libocedrus bidwillii* are met with, just as they are at the 3,000-foot level in the beech woods four and one-half miles up the Ruapehu track. Tree ferns are fairly common all the way up the ridge but are at their best on the lower slopes where some specimens of *Cyathea dealbata* and *Hemitelia smithii* have trunks 10 to 15 feet high. There is also a sprinkling of *Dicksonia squarrosa* but only an occasional *Dicksonia fibrosa*, although the latter is very common in the damp area at the base of the ridge.

On the summit occur fairly big trees of rimu, matai, miro, totara, rata, and *Libocedrus* but not growing so close together as in the forest below; black maire (*Olea cunninghamii*) is present in fair quantity; many *Weinmannia racemosa* trees; *Nothopanax arboreum* and *N. colensoi*, together with many of their seedlings; *Myrsine salicina;* much *Brachyglottis repanda;* a fair number of small-sized *Carpodetus serratus;* numerous small *Fuchsia* trees; a few low shrubs of *Pennantia corymbosa;* some *Melicytus ramiflorus;* shrubs of *Alseouosmia macrophylla* fairly common; in damp places, some young shrubs of *Schefflera digitata;* several big *Drimys colorata;* many small *Aristotelia racemosa;* many shrubs of *Coprosma grandifolia,* and, especially, of *C. tenuifolia* and *C. fœtidissima,* these three latter species forming most of the undershrub; big patches of *Lomaria discolor,* and, in damp places, of *Polystichum vestitum,* the tufts of these two latter species forming a great part of the ground color; many tufts of single- and double-crape ferns; plenty of bush grass; abundance of mosses; plenty of *Asplenium bulbiferum;* many filmy ferns on the ground and on old logs.

Harris visited Raetihi Ridge on December 13 and 14, 1922, and collected in greater detail on November 20 and 30, 1923, and April 8, 1924.

November (late spring) records from the summit and the higher slopes of Raetihi Ridge.

Paracladura lobifera.
Dolichopeza parvicauda.
Macromastix atridorsum.
Macromastix fucata.
Limonia (Zelandoglochina) paradisea circumcincta.
Limonia (Zelandoglochina) huttoni.
Limonia (Zelandoglochina) melanogramma.
Limonia (Dicranomyia) annulifera.
Limonia (Dicranomyia) cuneipennis.
Limonia (Dicranomyia) gubernatoria.
Limonia (Dicranomyia) multispina.
Limonia (Dicranomyia) reversalis.
Limonia (Dicranomyia) semicuneata.
Limonia (Dicranomyia) subfasciata.
Limonia (Dicranomyia) tarsalba.
Discobola picta.
Discobola tesselata.

November (late spring) records from the summit and the higher slopes of Raetihi Ridge—Continued.

Rhamphophila sinistra.
Tinemyia margaritifera.
Austrolimnophila argus.
Austrolimnophila chrysorrhœa.
Austrolimnophila geographica.
Austrolimnophila marshalli.
Austrolimnophila nigrocincta.
Austrolimnophila stemma.
Acantholimnophila maorica.
Heterolimnophila truncata.
Metalimnophila howesi.
Metalimnophila unipuncta.
Gynoplistia (Gynoplistia) sackeni.
Atarba filicornis.
Atarba viridicolor.
Molophilus flagellifer.
Molophilus hexacanthus.
Molophilus tenuistylus.
Amphineurus (Amphineurus) hudsoni.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) harrisi.
Amphineurus (Nothormosia) insulsus.

April (fall) records from the summit and the slopes of Raetihi Ridge (records based on the collection made April 8, 1924).

Paracladura obtusicornis.
Paracladura macrotrichiata.
Limonia (Zelandoglochina) cubitalis.
Discobola tesselata.
Amphineurus (Nesormosia) fatuus.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) insulsus.

KARIOI

The following observations on conditions at Karioi are by Mr. Mundy:

Karioi lies about 6 miles eastward of Ohakune and here the forest ends, giving place to open, grassy, pumice plains. The Karioi "bush," at an elevation of 2,100 to 2,200 feet, consists of beech woods, with *Nothofagus fusca* as the dominant tree, but intermixed with many trees of *N. menziesii.* Within the woods, a damp low drainage area is found where the bush soil is water-logged and consequently contains the plant species that can endure such conditions; for example, *Fuchsia, Schefflera,* and *Polystichum vestitum,* the last named being very abundant, with the tufts nearly touching. When fairly in this damp portion, no tufts of the common *Lomaria discolor* are found, its place being taken by the *Polystichum.* No taxad trees (rimu, matai, miro, etc.) are found, and black maire and hinau likewise seem to be absent, but a few young contorted pokakas are present. Tawa, *Pennantia,* and *Paratrophis* are absent and the only species of tree fern to be seen is *Dicksonia fibrosa,* which is here in great numbers. Many of Harris's crane flies were swept from the crowded clumps of *Polystichum* and others from beneath the dead, drooping fronds of *Dicksonia.*

Collections made in the red-beech forest (Nothofagus fusca) at Karioi.

EARLY SPRING (NOVEMBER 7, 1923)

Mischoderus annuliferus.
Macromastix atridorsum.
Limonia (Zelandoglochina) cubitalis.
Limonia (Zelandoglochina) huttoni.
Limonia (Zelandoglochina) melanogramma.
Limonia (Dicranomyia) luteipes.
Limonia (Dicranomyia) multispina.
Limonia (Dicranomyia) reversalis.
Limonia (Dicranomyia) tarsalba.
Discobola tesselata.
Tinemyia margaritifera.
Austrolimnophila argus.
Austrolimnophila cyatheti.
Austrolimnophila hudsoni atripes.
Austrolimnophila geographica.
Acantholimnophila maorica.
Limnophila quaesita.
Gynoplistia (Gynoplistia) luteicincta.
Gynoplistia (Gynoplistia) sackeni.
Atarba viridicolor.
Trimicra inconstans.
Molophilus flagellifer.
Molophilus flavidulus.
Molophilus howesi.
Molophilus multicinctus.
Molophilus plagiatus.
Molophilus sublateralis.
Molophilus sylvicolus.
Amphineurus (Amphineurus) hudsoni.
Amphineurus (Nothormosia) harrisi.
Amphineurus (Nothormosia) insulsus.

FALL (APRIL 14, 1924)

Paracladura macrotrichiata.
Paracladura obtusicornis.
Limonia (Dicranomyia) gubernatoria.
Limonia (Dicranomyia) tristigmata.
Limonia (Dicranomyia) vicarians.
Nothophila fuscana.
Molophilus luteipygus.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) harrisi.
Amphineurus (Nothormosia) insulsus.
Amphineurus (Nothormosia) nothofagi.

WINTER TIPULOIDEA

The open winters, with few snowfalls and killing frosts, enable a number of spring and fall species to persist into or even throughout the winter months. A few additional species, moreover, are eminently characteristic of the winter season. These are indicated by an asterisk in the accompanying list. Especially noteworthy are the species of *Paracladura,* the various *Macromastix,* and the magnificent *Gynoplistia hiemalis.*

Paracladura complicata.
Paracladura lobifera.
Paracladura maori.
Paracladura obtusicornis.
Zelandotipula novaræ.
* *Macromastix binotata.*

* *Macromastix halterata.*
* *Macromastix longioricornis.*
* *Macromastix monstrata.*
* *Macromastix sessilis.*
* *Macromastix simillima.*
Limonia (Zelandoglochina) cubitalis.
Limonia (Dicranomyia) ægrotans.
Limonia (Dicranomyia) luteipes.
Limonia (Dicranomyia) sulphuralis cholorophylloides.
Limonia (Dicranomyia) vicarians.
Limonia (Dicranomyia) weschei.
Discobola ampla.
Discobola tesselata.
Gynoplistia (Paralimnophila) skusei.
* *Gynoplistia (Gynoplistia) hiemalis.*
* *Gynoplistia (Gynoplistia) ocellifera.*
Gynoplistia (Gynoplistia) sackeni.
Ischnothrix connexa.
Molophilus flavidulus.
Molophilus multicinctus.
Molophilus macrocerus.
Molophilus tanypus coloratus.
Amphineurus (Nothormosia) gracilisentis.
Amphineurus (Nothormosia) harrisi.
Amphineurus (Nothormosia) insulsus.

There are several additional species of *Macromastix* in New Zealand that are characteristic winter species, but these have not yet been taken in the Ohakune district.

ANNOTATED LIST OF SPECIES

In the accompanying list the families and the genera are arranged in their phylogenetic sequence, so far as this can be determined at present from a study of the adults alone. Species are arranged alphabetically under each genus. A majority of the species were originally described from material taken within the faunal limits of the district; each name of such species is followed by an asterisk. For a common species with numerous records a range of dates is given, since to give only the two extremes would be highly misleading as to whether the species concerned was actually double brooded or had an unusually wide seasonal distribution. The approximate altitude of all Ohakune records is 2,060 feet.

TANYDERIDÆ

1. MISCHODERUS ANNULIFERUS (Hutton).

Tanyderus annuliferus HUTTON, Trans. N. Z. Inst. 32 (1900) 48-49.

The commonest species of the genus. Numerous specimens from Ohakune, mostly taken by beating in the bush; occurs almost throughout the growing season: October 27, 1921; November 16, December 1 and 31, and February 18, 1922; March 11, 1923. In beech forest, Karioi, November 7, 1923.

2. MISCHODERUS FORCIPATUS (Osten Sacken).

Tanyderus forcipatus OSTEN SACKEN, Verh. zool.-bot. Gesell. Wien for 1879, 29 (1880) 520.

"Found hanging on small bushes near edge of creek. Found only on two or three nights, but on one night they were fairly numerous. They were sluggish and easily caught while hanging by a leg or two to the bushes, mostly low down."—*Harris*. Ohakune, October 20, 1921.

TRICHOCERIDÆ

3. PARACLADURA APERTA (Alexander).*

Trochocera aperta ALEXANDER, Insec. Inscit. Menst. 10 (1922) 198–199.

Type locality: Ohakune, May 7, 1922. No additional material taken.

4. PARACLADURA COMPLICATA Alexander.*

Paracladura complicata ALEXANDER, Insec. Inscit. Menst. 12 (1924) 13.

Type locality: Ohakune, May 10, 1923.

5. PARACLADURA LOBIFERA (Alexander).

Trichocera lobifera ALEXANDER, Insec. Inscit. Menst. 10 (1922) 146–147.

Ohakune, November 14–16, 1922, beating in bush; June 13, 1923. Raetihi Hill, November 10, 1923.

6. PARACLADURA MACROTRICHIATA (Alexander).*

Trichocera macrotrichiata ALEXANDER, Insec. Inscit. Menst. 10 (1922) 199.

Type locality: Ohakune, April 10, 1922. Karioi, in beech forest, April 14, 1924. Raetihi Hill, April 8, 1924. Ruapehu, altitude 4,000 feet, January 4, 1924.

7. PARACLADURA MAORI (Alexander).

Trichocera maori ALEXANDER, Insec. Inscit. Menst. 9 (1921) 159–160.

Ohakune, May 16, 1923; July, 1921.

8. PARACLADURA OBTUSICORNIS (Alexander).*

Trichocera obtusicornis ALEXANDER, Insec. Inscit. Menst. 10 (1922) 146.

Type locality: Ohakune, July, 1921. Ohakune, May 2–10, 1923. Karioi, in beech forest, April 14, 1924. Raetihi Hill, April 8, 1924.

TIPULIDÆ

TIPULINAE

Tribe TIPULINI

9. DOLICHOPEZA (DOLICHOPEZA) ATROPOS (Hudson).

Tipula atropos HUDSON, Trans. N. Z. Inst. 27 (1895) 295.

Ohakune, November 18, 1922. Ruapehu, 4,500 feet, February 26, 1922. "Caught these at night with a light; they occurred in a damp spot where a small creek flowed over moss into a larger one; one individual flew and settled low down on the trunk of a tree, head up, all legs on support, wings spread out."—*Harris.*

10. DOLICHOPEZA (DOLICHOPEZA) PARVICAUDA Edwards.

Dolichopeza parvicauda EDWARDS, Trans. N. Z. Inst. 54 (1923) 330–331.

Ohakune, November 3, 1921; November 14–22 and December 1–5, 1922. Raetihi Hill, 2,800 feet, December 14, 1922; November 20–30, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

11. ACRACANTHA (AUSTROTIPULA) HUDSONI (Hutton).

Pachyrhina hudsoni HUTTON, Trans. N. Z. Inst. 32 (1900) 24–25.

Ohakune, January 8, 1923. "Swampy patch in open." *Harris.*

12. ZELANDOTIPULA NOVARÆ (Schiner).

Tipula novaræ SCHINER, Reise der Novara, Dipt. (1868) 37.

Ohakune, October 14–27, 1921; October 18–25, November 20–23, and February 3, 1922; March 17, 1924; April 30, 1923; May 3, 1922; July, 1921. "When at rest usually hold wings folded over back but sometimes outspread. Occur in many situations on fences, walls, bushes, etc."—*Harris.*

13. MACROMASTIX (AUROTIPULA) BIVITTATA Edwards.*

Macromastix bivittata EDWARDS, Ann. & Mag. Nat. Hist. IX 11 (1923) 629–630.

Type locality: Waimarino and Kaitoka, January, 1922 (*Hudson*).

14. MACROMASTIX (AUROTIPULA) DUX (Kirby).

Tipula dux KIRBY, Trans. Ent. Soc. London (1884) 270–271.

Ohakune, March 7, 1923.

15. MACROMASTIX (AUROTIPULA) FERRUGINOSA RUAPEHUENSIS Alexander.*

Macromastix ferruginosa ruapehuensis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 208.

Type locality: Ruapehu, 4,000 to 5,000 feet, January, 1921 (*Watt*). Ruapehu, 4,000 to 4,500 feet, January 20, 1924 (*Harris*).

16. **MACROMASTIX (CHLOROTIPULA) ELONGATA Edwards.***

Macromastix elongata EDWARDS, Ann. & Mag. Nat. Hist. IX 11 (1923) 630–631.

Type locality: Whakapapa, Ruapehu, 3,700 feet, January 9, 1922 (*Stella Hudson*).

17. **MACROMASTIX (CHLOROTIPULA) HOLOCHLORA HOLOCHLORA (Nowicki).**

Tipula holochlora NOWICKI, Beitr. zur Kenntniss der Dipt. Neuseelands (1875) 9.

Ohakune, December 13, 1922. Ruapehu, beech forest, 3,000 to 4,000 feet, January 12, 1923.

17a. **MACROMASTIX (CHLOROTIPULA) HOLOCHLORA ANGUSTIOR Alexander.***

Macromastix holochlora angustior ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 212.

Type locality: Ohakune, December 31, 1922, to January 5, 1923.

18. **MACROMASTIX (CHLOROTIPULA) VIRIDIS (Walker).**

Tipula viridis WALKER, Ins. Saundersiana, Dipt. (1856) 445.

Ohakune, October 27–29, 1921; October 18–29, 1922; November 6–15, 1921; November 26 and January 11, 1922. Raetihi Hill, 2,800 feet, December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 20, 1924. "February, 1922—Common for some time past on walls, bushes, and fences. When at rest, the wings are held spread out. Have reared them from pupæ found in decaying wood."—*Harris*.

19. **MACROMASTIX (MACROMASTIX) ALBIPLAGIA ALBIPLAGIA Alexander.***

Macromastix albiplagia ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 202–203.

Type locality: Ohakune, January 18 to February 14, 1922. Ohakune, February 3, 1922.

19a. **MACROMASTIX (MACROMASTIX) ALBIPLAGIA OBLITERATA Alexander.***

Macromastix albiplagia obliterata ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 203–204.

Type locality: Ohakune February 9–16, 1922. "February 24, 1922—These are very plentiful at present; about fifty on the walls of the house at dusk to-night, holding on with all the legs, the wings outspread. They also rest on bushes, weeds, grass, etc., and are rather quick in flight. They flutter actively about, probably seeking their mates."—*Harris*.

20. MACROMASTIX (MACROMASTIX) ANGUSTICOSTA Alexander.*

Macromastix angusticosta ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 110–111.

Type locality: Ohakune, December 23, 1921.

21. MACROMASTIX (MACROMASTIX) ATRIDORSUM Alexander.*

Macromastix atridorsum ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 314–315.

Macromastix harrisi ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 98–99.

Spring. Type locality: Ohakune, October 10 and November 13, 1921. Karioi, in beech forest, November 7, 1923; very common and variable. Raetihi Hill, 2,800 feet, November 20–30, 1923.

22. MACROMASTIX (MACROMASTIX) BINOTATA Hutton.

Macromastix binotata HUTTON, Trans. N. Z. Inst. 32 (1900) 32.

Late fall and winter. Ohakune, May 11–30, 1922; May 16 and June 13, 1923. "These are the first of the winter tipulids. The males are found on fences during the daytime, legs and wings outspread. The nearly wingless females were found in the mill, around stacked timber, not far above the ground following a hard frost. One isolated female laid 258 eggs. Thinking that possibly I might find them mating at night, I spent an hour and a half searching the same place one night last week. I came across one female about four feet above the ground, the highest I have yet found them. The numerous blackish eggs are very hard so one could walk on them on the ground without breaking them."—*Harris*.

23. MACROMASTIX (MACROMASTIX) FLAVIDIPENNIS Alexander.*

Macromastix flavidipennis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 201–202.

Type locality: Ohakune, January 28, 1922.

24. MACROMASTIX (MACROMASTIX) FUCATA Hutton.

Macromastix fucata HUTTON, Trans. N. Z. Inst. 32 (1900) 31.

Mount Ruapehu, January 1, 1922 (*C. C. Fenwick*). Raetihi Hill, 2,800 feet, November 20, 1923.

25. MACROMASTIX (MACROMASTIX) HALTERATA Alexander.*

Macromastix halterata ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 109–110.

Late fall and winter. Type locality: Ohakune, July, 1921; May 21–28, 1922. Ohakune, May 7–11, 1922; May 10 and June 13, 1923; July 17, 1923, in bush. "I get this species flattened out on the large leaves of shrubs in the bush; when at rest both wings and legs are spread wide apart."—*Harris*.

26. MACROMASTIX (MACROMASTIX) HUTTONI Edwards.

Macromastix huttoni EDWARDS, Trans. N. Z. Inst. **54** (1923) 342–343.

Summer. Ohakune, November 16, 1921; January 7–18 and February 8, 1922.

27. MACROMASTIX (MACROMASTIX) LONGIORICORNIS Alexander.*

Macromastix longioricornis ALEXANDER, Ann. & Mag. Nat. Hist. IX **11** (1923) 108–109.

Late fall and winter. Type locality: Ohakune, July, 1921; May 17, 1922.

28. MACROMASTIX (MACROMASTIX) LUNATA LUNATA Hutton.

Macromastix lunata HUTTON, Trans. N. Z. Inst. **32** (1900) 32.

Summer. Ohakune, November 25, 1922; December 25, 1921; December 1–17, 1922. Raetihi Hill, December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12–15, 1923.

28a. MACROMASTIX (MACROMASTIX) LUNATA FUSCOLATERA Alexander.

Macromastix lunata fuscolatera ALEXANDER, Ann. Ent. Soc. America **15** (1922) 236.

Type locality: Ruapehu, 4,000 to 5,000 feet, January, 1921 (*Watt*).

29. MACROMASTIX (MACROMASTIX) MONSTRATA Alexander.*

Macromastix monstrata ALEXANDER, Ann. & Mag. Nat. Hist. IX **13** (1924) 522–523.

Winter. Type locality: Ohakune, July 17, 1923.

30. MACROMASTIX (MACROMASTIX) OHAKUNENSIS Alexander.*

Macromastix ohakunensis ALEXANDER, Ann. & Mag. Nat. Hist. IX **11** (1923) 204–205.

Type locality: Ohakune, December 25, 1921.

31. MACROMASTIX (MACROMASTIX) SESSILIS Alexander.*

Macromastix sessilis ALEXANDER, Ann. & Mag. Nat. Hist. **13** (1924) 379–380.

Type locality: Ohakune, May 10, 1923.

32. MACROMASTIX (MACROMASTIX) SIMILLIMA Alexander.*

Macromastix simillima ALEXANDER, Ann. & Mag. Nat. Hist. IX **13** (1924) 521–522.

Winter. Type locality: Ohakune, August 10, 1922. Owhango, July 1, 1922. Waiouru, June 11, 1923.

33. MACROMASTIX (MACROMASTIX) SINCLAIRI Edwards.

Macromastix sinclairi EDWARDS, Trans. N. Z. Inst. **54** (1923) 350.

Taihape, common, March 5, 1923.

34. **MACROMASTIX (MACROMASTIX) SUBMANCA Alexander.***

Macromastix submanca ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 112.

Early spring. Type locality: Ohakune, October 19, 1922.

35. **HUDSONIA ÆNIGMATICA Alexander.***

Hudsonia ænigmatica ALEXANDER, Ann. & Mag. Nat. Hist. IX 17 (1926) 547–548.

Type locality: Ohakune, January 31, 1924.

LIMONIINÆ

Tribe LIMONIINI

36. **LIMONIA (ZELANDOGLOCHINA) CUBITALIS (Edwards).**

Dicranomyia cubitalis EDWARDS, Trans. N. Z. Inst. 54 (1923) 275–276.

Common, especially in the spring and fall, in the bush lingering into the winter. Ohakune, October 15–24 and November 18, 1921; April 4, May 17, and July 11–17, 1923. Waiouru, May 26, 1923. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, April 8, 1924. Ruapehu, February 25, 1922. "Get these at night, hanging on small bushes in the forest."—*Harris.*

37. **LIMONIA (ZELANDOGLOCHINA) HARRISI (Alexander).***

Dicranomyia harrisi ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 195–196.

Type locality: Ohakune to the mountain hut on Ruapehu, 3,000 to 4,000 feet, January 12, 1923. Ohakune, December 31, 1922.

38. **LIMONIA (ZELANDOGLOCHINA) HUTTONI (Edwards).**

Dicranomyia huttoni EDWARDS, Trans. N. Z. Inst. 54 (1923) 276.

Spring and early summer. Ohakune, November 14 and December 5, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, November 30, 1923; December 14, 1922. Ohakune to mountain hut on Ruapehu, 3,000 to 4,000 feet, January 12, 1923.

39. **LIMONIA (ZELANDOGLOCHINA) MELANOGRAMMA (Edwards).**

Dicranomyia melanogramma EDWARDS, Trans. N. Z. Inst. 54 (1923) 276–277.

Spring and early summer. Ohakune, November 14 and December 1–13, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 30, 1923. Ohakune to mountain hut on Ruapehu, beech zone, January 12, 1923.

40. LIMONIA (ZELANDOGLOCHINA) PARADISEA CIRCUMCINCTA (Alexander).*

Dicranomyia paradisea circumcincta ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 561–562.

Type locality: Summit of Raetihi Hill, 2,800 feet, November 20–30, 1923.

41. LIMONIA (DICRANOMYIA) ÆGROTANS (Edwards).

Dicranomyia ægrotans EDWARDS, Trans. N. Z. Inst. 54 (1923) 280–281.

Spring and fall. Ohakune, October 10–29 and November 1–15, 1921; December 4, 1922; April 4 and May 16, 1923. Taihape, May 19, 1923.

42. LIMONIA (DICRANOMYIA) ANNULIFERA (Alexander).

Dicranomyia annulifera ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 87.

Raetihi Hill, summit, 2,800 feet, November 20, 1923.

43. LIMONIA (DICRANOMYIA) BROOKESI (Edwards).

Dicranomyia brookesi EDWARDS, Trans. N. Z. Inst. 54 (1923) 281.

Ohakune, October 20, 1921.

44. LIMONIA (DICRANOMYIA) CUNEIPENNIS (Alexander).*

Dicranomyia cuneipennis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 99–100.

Type locality: Ohakune, November 16, 1922. Raetihi Hill, 2,800 feet, November 20, 1923.

45. LIMONIA (DICRANOMYIA) DIVERSISPINA (Alexander).*

Dicranomyia diversispina ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 197–198.

Type locality: Ohakune, October 31, 1922.

46. LIMONIA (DICRANOMYIA) FASCIATA (Hutton).

Dicranomyia fasciata HUTTON, Trans. N. Z. Inst. 32 (1900) 34.

A single female, Ohakune, November 13, 1922.

47. LIMONIA (DICRANOMYIA) GUBERNATORIA (Alexander).

Dicranomyia gubernatoria ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 363–364.

Karioi, in beech forest, April 14, 1924. Raetihi Hill, 2,800 feet, November 30, 1923.

48. LIMONIA (DICRANOMYIA) HETERACANTHA (Alexander).*

Dicranomyia heteracantha ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 195.

Type locality: Ohakune, January 28, 1922.

49. LIMONIA (DICRANOMYIA) LUTEIPES (Alexander).*

Dicranomyia luteipes ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 196–197.

Type locality: Ohakune, November 18, 1921; December 10, 1922. Ohakune, May 16 and June 13, 1923. Karioi, in beech forest, November 7, 1923. The allotype female was associated with *Limonia* (*Dicranomyia*) *torrens* near a waterfall.

50. **LIMONIA (DICRANOMYIA) MEGASTIGMOSA (Alexander).**

Dicranomyia megastigmosa ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 557–558.

Ruapehu, 4,500 feet, February 26, 1922; January 14, 1923; January 20, 1924. "On underside of rocks in creek; wings folded over back when at rest."—*Harris*. This crane fly is a characteristic mountain species. It is very closely allied to *L.* (*D.*) *sperata* Alexander, and the exact relationships between the two are still uncertain.

51. **LIMONIA (DICRANOMYIA) MŒSTA (Alexander).***

Dicranomyia mœsta ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 193–194.

Type locality: Ohakune, February 8, 1922.

52. **LIMONIA (DICRANOMYIA) MULTISPINA (Alexander).***

Dicranomyia multispina ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 509–510.

Type locality: Ohakune, October 1, 1921. Ohakune, November 14 and December 31, 1922; January 5, 1923. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 30, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

53. **LIMONIA (DICRANOMYIA) NEPHELODES (Alexander).***

Dicranomyia nephelodes ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 84–85.

Type locality: Ohakune, September 30 to October 27, 1921.

54. **LIMONIA (DICRANOMYIA) NIGRESCENS (Hutton).**

Dicranomyia nigrescens HUTTON, Trans. N. Z. Inst. 32 (1900) 34.

Ohakune, September 25, 1922; "taken at night, hanging over water."—*Harris*.

55. **LIMONIA (DICRANOMYIA) PUNCTIPENNIS MAORIENSIS (Alexander).***

Dicranomyia punctipennis maoriensis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 98.

Type locality: Ohakune, October 10, 1922; November 6–13, 1921. Taihape, October 18, 1922. "Taken in daytime in a swampy bulrush patch in open."—*Harris*.

56. **LIMONIA (DICRANOMYIA) PENDULIFERA (Alexander).**

Dicranomyia pendulifera ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 379–380.

Ohakune, October 11 and November 16, 1921.

57. **LIMONIA (DICRANOMYIA) REPANDA (Edwards).**

Dicranomyia repanda EDWARDS, Trans. N. Z. Inst. 54 (1923) 278.

A spring species. Ohakune, October 1–21 and November 8–13, 1921; October 31 to November 16, 1922.

58. **LIMONIA (DICRANOMYIA) REVERSALIS (Alexander).***

Dicranomyia reversalis ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 507–508.

Type locality: Ohakune, October 10, 1921. Taihape, October 12, 1921. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 30, 1923. Ruapehu beech zone, January 12, 1923.

59. **LIMONIA (DICRANOMYIA) SEDUCTA (Alexander).***

Dicranomyia seducta ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 97–98.

Type locality: Ohakune, December 25, 1921. Ohakune, December 1–31, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923. "These rest on spider webs; legs outspread; wings folded over body."—*Harris.*

60. **LIMONIA (DICRANOMYIA) SEMICUNEATA (Alexander).***

Dicranomyia semicuneata ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 564–565.

Type locality: Raetihi Hill, 2,800 feet, November 20–30, 1923.

61. **LIMONIA (DICRANOMYIA) SPERATA (Alexander).**

Dicranomyia sperata ALEXANDER, Ann. Ent. Soc. America 15 (1922) 224–225.

A characteristic mountain species. Ruapehu, 4,000 to 4,500 feet, January 20, 1924; 4,500 feet, February 26, 1922. "Secured at night with lamp, some on rocks near water, others in flight or resting on small bushes."—*Harris.*

62. **LIMONIA (DICRANOMYIA) SPONSA (Alexander).***

Dicranomyia sponsa ALEXANDER, Insec. Inscit. Menst. 10 (1922) 199–200.

Type locality: Ohakune, April 10, 1922. Ohakune, May 16, 1922.

63. **LIMONIA (DICRANOMYIA) SUBFASCIATA (Alexander).***

Dicranomyia subfasciata ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 563–564.

Type locality: Raetihi Hill, 2,800 feet, November 20–30, 1923.

64. **LIMONIA (DICRANOMYIA) SUBVIRIDIS (Alexander).**

Dicranomyia subviridis ALEXANDER, Ann. Ent. Soc. America 15 (1922) 223–224.

One female, Ohakune, October 29, 1921.

65. LIMONIA (DICRANOMYIA) SULPHURALIS CHLOROPHYLLOIDES (Alexander).

Dicranomyia sulphuralis chlorophylloides ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 67.

Spring and early summer. Ohakune, September 21 to October 13, 1921; November 14–24 and January 24, 1922; July 17, 1923, in bush. One specimen has cell 1st M_2 open in both wings.

66. LIMONIA (DICRANOMYIA) TARSALBA (Alexander).*

Dicranomyia tarsalba ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 505–506.

Type locality: Ohakune, November 10, 1921. Ohakune, November 14–16, 1922; November 22, 1922, in a half-dry patch of swampy ground, chiefly toetoe (*Arundo conspicua* Forster f.), with a few trees and shrubs; December 13, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 20–30, 1923.

67. LIMONIA (DICRANOMYIA) TORRENS (Alexander).*

Dicranomyia torrens ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 194–195.

Type locality: Ohakune, November 18–20, 1921. "These were swarming up and down the damp face of a papa-rock cliff near a small waterfall; many were mating or attempting copulation, while others were walking about on the face of the cliff."—*Harris.*

68. LIMONIA (DICRANOMYIA) TRISTIGMATA (Alexander).*

Dicranomyia tristigmata ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 68–69.

Type locality: Karioi, in beech forest, April 14, 1924.

69. LIMONIA (DICRANOMYIA) VICARIANS (Schiner).

Limnobia vicarians SCHINER, Reise der Novara, Dipt. (1868) 46.

Occurs in the spring and fall and is presumably double brooded. Ohakune, September 26 to October 15, 1921; May 2–23 and June 13, 1923. Taihape, May 19, 1923. Karioi, in beech forest, April 14, 1924.

70. LIMONIA (DICRANOMYIA) WESCHEI (Edwards).

Dicranomyia weschei EDWARDS, Trans. N. Z. Inst. 54 (1923) 284.

A fall species appearing earlier in the season at higher altitudes. Ohakune, May 9–16 and June 13, 1923. Taihape, May 19, 1923; Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

71. DISCOBOLA AMPLA (Hutton).

Trochobola ampla HUTTON, Trans. N. Z. Inst. 32 (1900) 36–37.

This striking crane fly is commonest in the spring and fall and is presumably double brooded. In the bush it persists into

the winter months. Ohakune, October 10–25, 1921; October 18 to November 26, 1922; December 23, 1921; May 7, 1922; June 13, 1923; July, 1921. Owhango, April 7, 1922; "wings folded over back, legs stretched in all directions." Ruapehu, beech zone, 3,000 to 4,000 feet, January 15, 1923; 4,500 feet, night of February 26, 1922; "hanging with a few legs on a small beech near creek."—*Harris.*

72. **DISCOBOLA GIBBERA Edwards.**

Discobola gibbera EDWARDS, Trans. N. Z. Inst. 54 (1923) 286.

A spring species. Ohakune, October 10–19 and November 3–28, 1921; December 2, 1922; December 23, 1921.

73. **DISCOBOLA PICTA (Hutton).**

Trochobola picta HUTTON, Trans. N. Z. Inst. 32 (1900) 37.

A spring species. Ohakune, October 10–27 and November 3–16, 1921; November 26, 1922. Raetihi Hill, November 30, 1923; December 14, 1922, on shrubs in bush.

74. **DISCOBOLA TESSELATA Osten Sacken.**

Trochobola tesselata OSTEN SACKEN, Berlin. Ent. Zeitschr. 39 (1894) 266.

This abundant species occurs almost throughout the year. Ohakune, September 19 and October 20, 1921; November 22, 1922; December 23–25, 1921; January 11–24 and April 9, 1922; May 11, 1922, " on tree-trunks at night, some bobbing up and down;" July, 1921. Karioi, in beech forest, November 7, 1923. Raetihi Hill, November 30 to December 14, 1923, beating shrubs in bush. Ruapehu 2,500 feet, February 25, 1922; beech zone, 3,000 to 4,000 feet, January 12, 1923.

75. **HELIUS HARRISI (Alexander).***

Rhamphidia harrisi ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 98–99.

Type locality: Ohakune, December 1, 1921.

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76. **RHAMPHOPHILA SINISTRA (Hutton).**

Limnophila sinistra HUTTON, Trans. N. Z. Inst. 32 (1900) 40.

Spring and early summer. Ohakune, October 27 to November 16, 1921; October 18, November 22, December 31, and January 24, 1922; January 10, 1923. Raetihi Hill, 2,800 feet, November

20, 1923. Ruapehu, beech zone, January 15, 1923; January 20, 1924.

"These seem to vary somewhat in color. They appear to prefer the ground, although found in other situations. When at rest the legs are bent and the wings folded over the back. They invariably make short flights of a few yards and then settle but are fairly quick on the wing."—*Harris*.

77. **TINEMYIA MARGARITIFERA Hutton.**

Tinemyia margaritifera HUTTON, Trans. N. Z. Inst. 32 (1900) 44.

A spring species. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 20, 1923.

78. **NOTHOPHILA FUSCANA (Edwards).**

Ulomorpha fuscana EDWARDS, Trans. N. Z. Inst. 54 (1923) 305.

Late summer and fall. Ohakune, March 11, 1923, in bush; April 11, 1922. Karioi, in beech forest, April 14, 1924.

79. **AUSTROLIMNOPHILA ARGUS (Hutton).**

Limnophila argus HUTTON, Trans. N. Z. Inst. 32 (1900) 41.

Spring and early summer. Ohakune, September 19, October 25–30, and November 4–11, 1921; November 22, December 31, and January 9–24, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 to 4,500 feet, January 20, 1924.

80. **AUSTROLIMNOPHILA CHRYSORRHŒA (Edwards).**

Limnophila chrysorrhœa EDWARDS, Trans. N. Z. Inst. 54 (1923) 311–312.

An early summer mountain species. Raetihi Hill, November 20–30, 1923; December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; January 20, 1924.

81. **AUSTROLIMNOPHILA CYATHETI (Edwards).**

Limnophila cyatheti EDWARDS, Trans. N. Z. Inst. 54 (1923) 313–314.

Ohakune, March 11, 1923, in bush. Karioi, in beech forest, November 7, 1923; emerged from pupa found in decaying wood.

82. **AUSTROLIMNOPHILA GEOGRAPHICA (Hutton).**

Limnophila geographica HUTTON, Trans. N. Z. Inst. 32 (1900) 43–44.

Spring and early summer. Ohakune, November 18, 1921; November 1–22, December 5, and January 11, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, November 20–30, 1923; December 14, 1922.

83. **AUSTROLIMNOPHILA HUDSONI ATRIPES** (Alexander).*

Limnophila hudsoni atripes ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 92.

Late spring and early summer. Type locality: Ohakune, November 6–14, 1921. Ohakune, December 23–31, 1921; January 5, 1923. Karioi, in beech forest, November 7, 1923.

84. **AUSTROLIMNOPHILA LEUCOMELAS** (Edwards).

Limnophila leucomelas EDWARDS, Trans. N. Z. Inst. 54 (1923) 308.

Early summer. Ohakune, December 23, 1921; December 1–2, 1922. Raetihi Hill, December 14, 1922. Ruapehu, beech zone, January 12–15, 1923.

85. **AUSTROLIMNOPHILA MARSHALLI** (Hutton).

Limnophila marshalli HUTTON, Trans. N. Z. Inst. 32 (1900) 42.
Limnophila umbrosa HUTTON, Trans. N. Z. Inst. 32 (1900) 43.

Late spring and early summer. Ohakune, November 22, December 31, and January 9, 1922. Raetihi Hill, December 13–14, 1922; November 30, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

86. **AUSTROLIMNOPHILA NIGROCINCTA** (Edwards).

Limnophila nigrocincta EDWARDS, Trans. N. Z. Inst. 54 (1923) 312–313.

Late spring and early summer. Ohakune, November 12, 1921; December 5–13 and January 11, 1922. Raetihi Hill, November 20–30, 1923; December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

87. **AUSTROLIMNOPHILA OCULATA** (Edwards).

Limnophila oculata EDWARDS, Trans. N. Z. Inst. 54 (1923) 310–311.

Early summer. Ohakune, January 11–18, 1922. Ruapehu, 4,000 feet, January 15, 1923; "a pair in copula, resting on beech trunk; legs spread out flat, wings folded over back."—*Harris*.

88. **AUSTROLIMNOPHILA STEMMA** (Alexander).*

Limnophila stemma ALEXANDER, Insec. Inscit. Menst. 10 (1922) 201–202.

Type locality: Ohakune, November 18, 1921. Raetihi Hill, November 20–30, 1923; December 14, 1922; "taken near a spring on damp hillside in bush."—*Harris*.

89. **AUSTROLIMNOPHILA SUBINTERVENTA** (Edwards).

Limnophila subinterventa EDWARDS, Trans. N. Z. Inst. 54 (1923) 309.

Early summer. Raetihi Hill, December 13, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 feet, January 4, 1924.

90. **ACANTHOLIMNOPHILA MAORICA** (Alexander).*

Limnophila maorica ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 309–310.

Spring. Type locality: Ohakune, September 21 to October 11, 1921. Ohakune, October 19–20, 1921; October 22 to November 16, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, November 20–30, 1923.

91. **HETEROLIMNOPHILA SUBTRUNCATA** (Alexander).*

Limnophila subtruncata ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 199–200.

Type locality: Ohakune, January 18, 1922.

92. **HETEROLIMNOPHILA TRUNCATA** (Alexander).

Limnophila truncata ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 93–94.

Spring and early summer. Raetihi Hill, November 20–30, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; January 20, 1924.

93. **LIMNOPHILELLA DELICATULA** (Hutton).

Limnophila delicatula HUTTON, Trans. N. Z. Inst. 32 (1900) 42.

Spring and early summer. Ohakune, November 14–22 and December 1, 1922; January 5, 1923; "among ferns near creek; they seem to prefer damp places."—*Harris*. Raetihi Hill, December 14, 1922.

94. **LIMNOPHILA QUÆSITA** Alexander.*

Limnophila quæsita ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 109–110.

Type locality: Ohakune, November 8, 1922. Ohakune, October 30, 1923. Karioi, in beech forest, November 7, 1923.

95. **METALIMNOPHILA HOWESI** (Alexander).

Limnophila howesi ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 513–514.

Spring. Ohakune, November 14–22, 1922. Raetihi Hill, 2,800 feet, November 20–30, 1923.

96. **METALIMNOPHILA MIRIFICA** (Alexander).*

Limnophila mirifica ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 310–311.

Type locality: Ohakune, October 10, 1921. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 to 4,500 feet, January 20, 1924.

97. **METALIMNOPHILA NEMOCERA (Alexander).***

Limnophila nemocera ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 107–108.

Type locality: Ohakune, September 17, 1922.

98. **METALIMNOPHILA PROTEA Alexander.***

Metalimnophila protea ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 69–71.

Type locality: Ruapehu, beech zone, 3,000 to 4,000 feet, January 20, 1924.

99. **METALIMNOPHILA UNIPUNCTA (Alexander).**

Limnophila unipuncta ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 94–95.

Raetihi Hill, 2,800 feet, November 20, 1923.

100. **NOTHOLIMNOPHILA EXCLUSA (Alexander).***

Limnophila exclusa ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 517–518.

Type locality: Ohakune, November 12, 1921. Ohakune, December 10, 1922, beating in bush; January 4, 1922.

101. **ZELANDOMYIA CINEREIPLEURA (Alexander).**

Limnophila cinereipleura ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 92–93.

Late spring. Ohakune, November 22, 1922, in a half-dry swampy patch, chiefly toetoe (*Arundo conspicua* Forster f.), with a few trees and shrubs; December 1, 1922, on mint; December 5–10, 1922.

102. **ZELANDOMYIA PENTHOPTERA Alexander.***

Zelandomyia penthoptera ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 371–372.

Type locality: Ohakune, March 23 to April 6, 1923. Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

103. **ZELANDOMYIA PYGMÆA Alexander.***

Zelandomyia pygmæa ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 106–107.

Type locality: Ohakune, January 28, 1922.

104. **ZELANDOMYIA RUAPEHUENSIS (Alexander).***

Limnophila ruapehuensis ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 153–154.

Type locality: Ruapehu, 4,000 to 5,000 feet, January, 1921 (*Watt*). Ohakune, November 14–22, 1922. Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

105. **ZELANDOMYIA WATTI (Alexander).***

Limnophila watti ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 152–153.

Type locality: Ruapehu, 4,000 to 4,500 feet, January, 1921 (*Watt*). Ruapehu, beech zone, 3,000 to 4,000 feet, January 20, 1924.

106. GYNOPLISTIA (PARALIMNOPHILA) SKUSEI (Hutton).

Limnophila skusei HUTTON, Trans. N. Z. Inst. 34 (1902) 190–191.

Wide-spread throughout the season. Ohakune, October 11–15, 1921; October 18–31, 1922; November 16, 1921; January 10 and February 16, 1922. Taihape, May 6, 1922; "a few still about."—*Harris*. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923. "This species holds on flat surfaces with all legs on support, wings folded over body, the latter tilted at an angle of from 80° to 90°."—*Harris*.

107. GYNOPLISTIA (GYNOPLISTIA) BILOBATA Alexander.*

Gynoplistia bilobata ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 205.

Type locality: Ohakune, November 16–25, 1921; December 1, 1922.

108. GYNOPLISTIA (GYNOPLISTIA) BONA Alenxander.

Gynoplistia bona ALEXANDER, Insec. Inscit. Menst. 8 (1920) 123–125.

Late spring and early summer. Ohakune, December 1–31 and January 9–24, 1922; January 5–11, 1923; "rests with legs half-spread, wings folded over back."—*Harris*.

109. GYNOPLISTIA (GYNOPLISTIA) CONCAVA Alexander.*

Gynoplistia concava ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 311–312.

Spring. Type locality: Ohakune, October 3, 1921. Taihape, October 12–22, 1921. Ohakune, October 24, 1922.

110. GYNOPLISTIA (GYNOPLISTIA) ELUTA Alexander.*

Gynoplistia eluta ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 107–108.

Early summer. Type locality: Ohakune, December 20–25, 1921; Waimarino, January, 1922 (*Fenwick*). Ohakune, December 29, 1922; January 10, 1923.

111. GYNOPLISTIA (GYNOPLISTIA) FIMBRIATA Alexander.

Gynoplistia fimbriata ALEXANDER, Insec. Inscit. Menst. 8 (1920) 126–128.

Late spring and early summer. Ohakune, November 16, 1921; December 9, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 20, 1924.

112. GYNOPLISTIA (GYNOPLISTIA) FUSCOPLUMEA Edwards.

Gynoplistia fuscoplumbea EDWARDS, Trans. N. Z. Inst. 54 (1923) 318.

Late spring. Ohakune, November 18, 1921; December 1 and 2, 1922.

113. GYNOPLISTIA (GYNOPLISTIA) GLAUCA Edwards.

Gynoplistia glauca EDWARDS, Trans. N. Z. Inst. 54 (1923) 318.

Early summer. Ohakune, December 10 and January 4, 1922; January 15, 1923.

114. GYNOPLISTIA (GYNOPLISTIA) HARRISI Alexander.*

Gynoplistia harrisi ALEXANDER, Ann. Ent. Soc. America 15 (1922) 231–232.

Type locality: Ohakune, February, 1920.

115. GYNOPLISTIA (GYNOPLISTIA) HIEMALIS (Alexander).*

Cerozodia hiemalis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 108.

Gynoplistia hiemalis ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 372.

Winter. Type locality: Ohakune, July, 1921, in bush. The unique type, a female, was found hanging near the bottom of a small shrub near the ground. It was found in the daytime and was the only specimen observed. On June 14, 1923, Harris found five additional females. One of these was resting against a tree trunk, the beautiful male nearby, hanging to a small shrub by a couple of legs. These were taken at night; the male and a female were placed in a box and kept alive for a time to see if they would mate. Although very sluggish in the bush, the nearly apterous females became very lively in the observation boxes, but no mating occurred. On June 22, 1923, Harris found a second male. This was resting on a tree trunk, stowed away amongst some vines, the wings folded incumbent over the back, the legs spread apart. At about the same time, Dr. John G. Myers secured two additional males in the Wainui State Forest, Wellington. One of these was beaten from a dead tawa tree that had been recently felled, the second from the dead, hanging fronds of a tree fern (either *Hemitelia* or *Dicksonia squarrosa*).

116. GYNOPLISTIA (GYNOPLISTIA) INCISA Edwards.

Gynoplistia incisa EDWARDS, Trans. N. Z. Inst. 54 (1923) 318–319.

Ohakune, December 25, 1921.

117. GYNOPLISTIA (GYNOPLISTIA) LOBULIFERA Alexander.*

Gynoplistia lobulifera ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 209–210.

Type locality: Ohakune to the mountain hut on Ruapehu, beech zone, 3,000 to 4,500 feet, January 12–15, 1923.

118. GYNOPLISTIA (GYNOPLISTIA) LUTEICINCTA Alexander.*

Gynoplistia luteicincta ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 576–577.

Type locality: Ohakune, December 12, 1922. Karioi, in beech forest, November 7, 1923.

119. GYNOPLISTIA (GYNOPLISTIA) NIVEICINCTA Alexander.*

Gynoplistia niveicincta ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 519–520.

Type locality: Ohakune, December 15, 1919.

120. GYNOPLISTIA (GYNOPLISTIA) OCELLIFERA Alexander.*

Gynoplistia ocellifera ALEXANDER, Ann. & Mag. Nat Hist. IX 12 (1923) 111–112.

Type locality: Raurimu, June 7, 1922.

121. GYNOPLISTIA (GYNOPLISTIA) OROPHILA Edwards.*

Gynoplistia orophila EDWARDS, Ann. & Mag. Nat. Hist. IX 11 (1923) 628–629.

Type locality: Whakapapa, Ruapehu, altitude 4,000 feet, January, 1922 (*Hudson*).

122. GYNOPLISTIA (GYNOPLISTIA) PLEURALIS Alexander.*

Gynoplistia pleuralis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 208–209.

Type locality: Ohakune to the mountain hut on Ruapehu, beech zone, 3,000 to 4,500 feet, January 12–15, 1923.

123. GYNOPLISTIA (GYNOPLISTIA) RECURVATA Alexander.*

Gynoplistia recurvata ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 211–212.

Type locality: Ohakune, December 1–12, 1922, on mint.

124. GYNOPLISTIA (GYNOPLISTIA) SACKENI Alexander.

Gynoplistia sackeni ALEXANDER, Insec. Inscit. Menst. 8 (1920) 125–126.

Spring. Ohakune, September 29–30 and October 1–4, 1921. Karioi, in beech forest, November 7, 1923. Raetihi Hill, November 20–30, 1923.

125. GYNOPLISTIA (GYNOPLISTIA) SPINICALCAR Alexander.*

Gynoplistia spinicalcar ALEXANDER, Ann. Ent. Soc. America 15 (1922) 230–231.

Type locality: Ohakune, March 1, 1919.

126. **GYNOPLISTIA (GYNOPLISTIA) SPLENDENS Alexander.***

Gynoplistia splendens ALEXANDER, Ann. Ent. Soc. America **15** (1922) 233–234.

Type locality: Ohakune, February 15, 1920.

127. **GYNOPLISTIA (GYNOPLISTIA) SUBCLAVIPES Alexander.***

Gynoplistia subclavipes ALEXANDER, Ann. & Mag. Nat. Hist. IX **13** (1924) 373–375.

Type locality: Ohakune, December 17, 1922.

128. **GYNOPLISTIA (GYNOPLISTIA) SUBFASCIATA Walker.**

Gynoplistia subfasciata WALKER, List. Dipt. Brit. Mus. **1** (1848) 74.

Spring. Ohakune, November 16 and December 1, 1921.

129. **GYNOPLISTIA (GYNOPLISTIA) TRIDACTYLA Edwards.**

Gynoplistia tridactyla EDWARDS, Trans. N. Z. Inst. **54** (1923) 321.

Spring and fall. Ohakune, October 22, 1922; April 20, 1923.

130. **GYNOULISTIA (CEROZODIA) HUDSONI HEMIPTERA (Alexander).***

Cerozodia hudsoni hemiptera ALEXANDER, Insec. Inscit. Menst. **10** (1922) 203–204.

Type locality: Ruapehu, 4,000 to 5,000 feet, January, 1921 (*Watt*). Ohakune, January 11, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

131. **ISCHNOTHRIX CONNEXA (Alexander).***

Orolimnophila connexa ALEXANDER, Ann. & Mag. Nat. Hist. IX **11** (1923) 198–199.

Type locality: Ohakune, July, 1921. Ohakune, May 2, 1923. Horopito, 2,300 feet, February, 1922; "on uprights of water tank on wet morning."—*Harris*. Ruapehu, beech zone, 3,000 to 4,000 feet, February 26, 1922; 4,000 to 4,500 feet, January 20, 1924.

132. **ATARBA (ATARBA) FILICORNIS Alexander.**

Atarba filicornis ALEXANDER, Ann. & Mag. Nat. Hist. IX **9** (1922) 151–152.

Spring and early summer. Ohakune, November 8–26 and December 1, 1922; December 25, 1921; January 18, 1922. Raetihi Hill, 2,800 feet, November 20–30, 1923; December 14, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 feet, January 4, 1924.

133. **ATARBA (ATARBA) VIRIDICOLOR Alexander.***

Atarba viridicolor ALEXANDER, Ann. & Mag. Nat. Hist. IX **9** (1922) 308.

Spring. Type locality: Ohakune, October 11, 1921. Ohakune, November 3, 1921; November 24–26, 1922. Karioi, in beech

forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 20–30, 1923.

134. ELEPHANTOMYIA RUAPEHUENSIS Alexander.*

Elephantomyia ruapehuensis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 204–205.

Type locality: Ruapehu, beech zone, 3,000 to 4,000 feet, January 15, 1923. A second specimen, a male, was taken near the type locality, January 4, 1924, at an altitude of 4,000 feet.

135. ELEPHANTOMYIA ZEALANDICA Edwards.

Elephantomyia zealandica EDWARDS, Trans. N. Z. Inst. 54 (1923) 288.

Ohakune, December 7, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 20, 1924; 4,000 to 4,500 feet, January 20, 1924.

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136. CERATOCHEILUS LEVIS (Hutton).

Rhamphidia levis HUTTON, Trans. N. Z. Inst. 32 (1900) 38.

Ohakune, December 17, 1922; December 7, 1923.

137. CERATOCHEILUS OCHRACEUM Edwards.

Ceratocheilus ochraceum EDWARDS, Trans. N. Z. Inst. 54 (1923) 289.

Ruapehu, 4,000 to 5,000 feet, January, 1921 (*Watt*).

138. RHABDOMASTIX (SACANDAGA) OPTATA Alexander.*

Rhabdomastix optata ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 104–105.

Type locality: Ohakune, January 24 to February 8, 1922.

139. RHABDOMASTIX (SACANDAGA) TRICHIATA Alexander.*

Rhabdomastix trichiata ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 197–198.

Type locality: Ohakune, February 8, 1922. Ohakune, December 2, 1922.

140. RHABDOMASTIX (SACANDAGA) VITTITHORAX Alexander.*

Rhabdomastix vittithorax ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 105–106.

Type locality: Ohakune, January 28, 1922.

141. GONOMYIA (LIPOPHLEPS) LONGISPINA Alexander.*

Gonomyia longispina ALEXANDER, Insec. Inscit. Menst. 10 (1922) 201.

Type locality: Ohakune, April 9, 1922.

142. GONOMYIA (LIPOPHLEPS) NIGROHALTERATA Edwards.

Gonomyia nigrohalterata EDWARDS, Trans. N. Z. Inst. 54 (1923) 290.

Spring and early summer. Ohakune, November 24 and December 2, 1922. Taihape, October 14, 1921. Raetihi Hill, near base, December 13, 1922.

143. **CAMPBELLOMYIA ALPINA ALPINA (Alexander).**

Gnophomyia (?) *alpina* ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 565–566.

Ohakune, February 24, 1922.

143a. **CAMPBELLOMYIA ALPINA FULVIPLEURA (Alexander).***

Gnophomyia alpina fulvipleura ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 203–204.

Type locality: Ohakune, December 1, 1922.

143b. **CAMPBELLOMYIA ALPINA FUMIPENNIS (Alexander).***

Gnophomyia alpina fumipennis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 203.

Type locality: Ohakune, December 13, 1922.

144. **APHROPHILA FLAVOPYGIALIS (Alexander).**

Gnophomyia flavopygialis ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 150–151.

Summer. Ohakune, November 16 and December 25, 1921; December 1–29, 1922; January 28, 1921; February 1–5, 1922. Ruapehu, 4,000 feet, January 4, 1924.

145. **APHROPHILA NEOZELANDICA (Edwards).**

Gnophomyia (*Aphrophila*) *neozelandica* EDWARDS, Trans. N. Z. Inst. 54 (1923) 298.

Ohakune, February 8, 1922. Popaka, February, 1922. Ruapehu, 4,500 feet, February 26, 1922. "These skim along the surface of the water like a hydroplane. When resting, they settle on wet rocks, usually on the underside of an inclined bowlder. Mating takes place in similar situations."—*Harris.*

146. **TRIMICRA INCONSTANS Alexander.**

Trimicra inconstans ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 148–149.

Ohakune, November 1–16, 1921; February 8, 1922; April 4, 1923. Taihape, October 22, 1921. Karioi, in beech forest, November 7, 1923.

147. **TASIOCERA PAULULA (Alexander).***

Molophilus paululus ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 103–104.

Type locality: Ohakune, January 18, 1922.

148. **MOLOPHILUS AUCKLANDICUS Alexander.***

Molophilus aucklandicus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 106–107.

Type locality: Ruapehu, beech zone, 3,000 to 4,000 feet, February 26, 1922; 4,500 feet, February 27, 1922.

149. MOLOPHILUS BIDENS Alexander.*

Molophilus bidens ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 202.

Type locality: Ohakune, December 10, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

150. MOLOPHILUS BREVINERVIS Alexander.*

Molophilus brevinervis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 102–103.

Type locality: Ohakune, December 22, 1921.

151. MOLOPHILUS CRUCIFERUS Alexander.

Molophilus cruciferus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 147.

Ohakune, December 1, 1922.

152. MOLOPHILUS FLAGELLIFER Alexander.*

Molophilus flagellifer ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 560.

A characteristic mountain species. Type locality: Ruapehu, 3,700 feet, January 6, 1922 (*Watt*). Ohakune, November 14–24, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 20, 1923. Ruapehu, beech zone, January 12, 1923; February 26, 1922; 4,000 to 4,500 feet, January 4–20, 1924.

153. MOLOPHILUS FLAVIDULUS Alexander.*

Molophilus flavidulus ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 100.

Type locality: Ohakune, January 18, 1922. Ohakune, May 10, 1923. Karioi, in beech forest, November 7, 1923.

154. MOLOPHILUS FLAVOMARGINALIS Alexander.*

Molophilus flavomarginalis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 105–106.

Type locality: Ohakune, November 14, 1922.

155. MOLOPHILUS HARRISIANUS Alexander.*

Molophilus harrisianus ALEXANDER, Ann. & Mag. Nat. Hist. IX 15 (1925) 649–650.

Type locality: Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

156. MOLOPHILUS HEXACANTHUS Alexander.*

Molophilus hexacanthus ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 567.

Type locality: Raetihi Hill, 2,800 feet, November 20, 1923.

157. **MOLOPHILUS HILARIS Alexander.***

Molophilus hilaris ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 99–100.

Type locality: Ohakune, January 24, 1922. Ohakune, December 1, 1922.

158. **MOLOPHILUS HOWESI Alexander.**

Molophilus howesi ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 195–196.

Spring. Ohakune, November 14–24, 1922. Karioi, in beech forest, November 7, 1923.

159. **MOLOPHILUS IRREGULARIS Alexander.***

Molophilus irregularis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 196–197.

A characteristic mountain species. Type locality: Ruapehu, 4,500 feet. February 27, 1922. Ohakune, November 14–16 and December 1–17, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 to 4,500 feet, January 4–20, 1924.

160. **MOLOPHILUS LATIPENNIS Alexander.***

Molophilus latipennis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 198–199.

A characteristic mountain species. Type locality: Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923. Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

161. **MOLOPHILUS LUTEIPYGUS Alexander.***

Molophilus luteipygus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 510–511.

Karioi, in beech forest, April 14, 1924.

162. **MOLOPHILUS MACROCERUS Alexander.***

Molophilus macrocerus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 297–298.

Winter and early spring. Type locality: Ohakune, September 14 to October 15, 1921. Ohakune, June 13, 1923; July, 1921; July 11, 1923.

163. **MOLOPHILUS MOROSUS Alexander.**

Molophilus morosus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 104–105.

Ruapehu, 4,000 to 4,500 feet, January 20, 1924.

164. **MOLOPHILUS MULTICINCTUS Edwards.**

Molophilus multicinctus EDWARDS, Trans. N. Z. Inst. 54 (1923) 295.

Spring, fall, and early summer; presumably double brooded. Ohakune, September 23, 1921; October 10–31, 1921; November

12, 1922, on mint; November 14–30, December 2–17, and January 18–28, 1922; February 24, 1922, "about fifty or sixty of these were swarming over a damp patch, close to ground."—*Harris;* May 2–16, 1923. Karioi, in beech forest, November 7, 1923.

165. **MOLOPHILUS NIVEICINCTUS Alexander.***

Molophilus niveicinctus ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 560–561.

Type locality: Ruapehu, 3,700 feet, January 6, 1922 (*Watt*).

166. **MOLOPHILUS OHAKUNENSIS Alexander.***

Molophilus quadrifidus ohakunensis ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 102.

Type locality: Ohakune, February 9 to March 10, 1922. Ohakune, November 30, 1922.

167. **MOLOPHILUS OPPOSITUS Alexander.***

Molophilus oppositus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 201.

Type locality: Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

168. **MOLOPHILUS PARVULUS Alexander.***

Molophilus parvulus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 146.

Type locality: Ohakune, November 10, 1920.

169. **MOLOPHILUS PHILPOTTI Alexander.**

Molophilus philpotti ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 145–146.

Ruapehu, 3,700 feet, January 6, 1922 (*Watt*).

170. **MOLOPHILUS PLAGIATUS Alexander.***

Molophilus plagiatus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 301–302.

Spring, recurring in the fall; probably double brooded. Type locality: Ohakune, October 7–27, 1921. Ohakune, October 27, November 12–22, and December 23, 1922; April 4, 1923. Karioi, in beech forest, November 7, 1923.

171. **MOLOPHILUS PULCHERRIMUS Edwards.**

Molophilus pulcherrimus EDWARDS, Trans. N. Z. Inst. 54 (1923) 295.

Summer. Ohakune, December 17–31, 1922; December 7, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, January 15, 1923; February 27, 1922; 4,000 to 4,500 feet, January 20, 1924; February 26, 1922.

172 **MOLOPHILUS REPANDUS Alexander.***

Molophilus repandus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 103–104.

Type locality: Ohakune, November 14–16, 1922.

173. **MOLOPHILUS SECUNDUS Alexander.***

Molophilus secundus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 200.

Type locality: Ohakune, December 13, 1922.

174. **MOLOPHILUS SEPOSITUS Alexander.***

Molophilus sepositus ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 103.

Type locality: Ohakune, December 22, 1921.

175. **MOLOPHILUS SUBLATERALIS Alexander.***

Molophilus sublateralis ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 302–303.

Type locality: Ohakune, October 7–15, 1921. Ohakune, November 14, 1922. Karioi, in beech forest, November 7, 1923.

176. **MOLOPHILUS SYLVICOLUS Alexander.***

Molophilus sylvicolus ALEXANDER, Ann. & Mag. Nat. Hist. IX 13 (1924) 567–568.

Type locality: Karioi, in beech forest, November 7, 1923.

177. **MOLOPHILUS TANYPUS Alexander.***

Molophilus tanypus ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 298–299.

Spring. Type locality: Ohakune, September 23, 1921.

177a. **MOLOPHILUS TANYPUS COLORATUS Alexander.***

Molophilus tanypus coloratus ALEXANDER, Ann. & Mag. Nat. Hist. IX 11 (1923) 197.

Winter. Type locality: Ohakune, July, 1921.

178. **MOLOPHILUS TENUISSIMUS Alexander.***

Molophilus tenuissimus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 202–203.

Type locality: Ohakune, December 13, 1922.

179. **MOLOPHILUS TENUISTYLUS Alexander.***

Molophilus tenuistylus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 104.

Type locality: Ohakune, November 14–22, 1922. Ohakune, January 5, 1923. Raetihi Hill, 2,800 feet, November 30, 1923.

180. **MOLOPHILUS TERMINANS Alexander.***

Molophilus terminans ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 511–512.

Type locality: Ohakune, November 6–15, 1921. Ohakune, November 24 and December 10, 1922; January 5, 1923; "found

near a culvert over a small creek. When at rest, legs spread out, wings folded over back."—*Harris*.

181. MOLOPHILUS UNIPLAGIATUS Alexander.*

Molophilus uniplagiatus ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 199–200.

A characteristic mountain species. Type locality: Ruapehu, beech forest, 3,000 to 4,000 feet, December 31, 1922, to January 12–15, 1923. In same locality, January 21, 1923. Ruapehu, 4,000 to 4,500 feet, January 20, 1923.

182. AMPHINEURUS (AMPHINEURUS) HUDSONI Edwards.

Amphineurus hudsoni EDWARDS, Trans. N. Z. Inst. 54 (1923) 293.

Late spring and summer. Ohakune, November 22, 1922, in a half-dry swampy toetoe patch, with some trees and shrubs; February 20, 1922. Karioi, in beech forest, November 7, 1923. Raetihi Hill, 2,800 feet, November 20–30, 1923. Ruapehu, beech zone, January 12, 1923; January 4, 1924.

183. AMPHINEURUS (AMPHINEURUS) LYRIFORMIS Alexander.*

Amphineurus lyriformis ALEXANDER, Ann. & Mag. Nat. Hist. IX 12 (1923) 101.

Type locality: Ohakune, December 1, 1922. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 to 4,500 feet, January 4–20, 1924.

184. AMPHINEURUS (AMPHINEURUS) SENEX Alexander.

Amphineurus senex ALEXANDER, Ann. Ent. Soc. America 15 (1922) 225–226.

Ohakune, November 22, 1922, in a half-dry toetoe patch, with a few trees and shrubs. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; 4,000 to 4,500 feet, January 4–20, 1924.

185. AMPHINEURUS (NESORMOSIA) FATUUS (Hutton).

Rhypholophus fatuus HUTTON, Trans. N. Z. Inst. 34 (1900) 188.

Spring and early summer, recurring in the fall. Ohakune, November 22 and December 1–13, 1922; January 5, 1923. Raetihi Hill, 2,800 feet, April 8, 1924. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12–15, 1923; 4,000 to 4,500 feet, January 20, 1924.

186. AMPHINEURUS (NESORMOSIA) SUBFATUUS Alexander.*

Amphineurus subfatuus ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 87–88.

Spring and summer, possibly double brooded. Type locality: Ohakune, November 13, 1921, to February 20, 1922. Ohakune, November 14–22, 1922, the latter in a half-dry swampy patch, chiefly of toetoe (*Arundo conspicua* Forster f.), with a few trees and shrubs; December 13, 1922; February 20, 1923.

187. AMPHINEURUS (NOTHORMOSIA) FIMBRIATULUS Alexander.

Amphineurus (*Nothormosia*) *fimbriatulus* ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 75–76.

A paratype, Ohakune, March 8, 1923 (*Tonnoir*).

188. AMPHINEURUS (NOTHORMOSIA) GRACILISENTIS Alexander.*

Amphineurus gracilisentis ALEXANDER, Ann. & Mag. Nat. Hist. IX 10 (1922) 563.

Type locality: Ruapehu, 3,700 feet, January 6, 1922 (*Watt*); Ohakune, July, 1921. Common in the spring and fall, lingering into the winter months in the bush and into the summer in the mountains. Ohakune, November 14–18, 1921; December 1–13, 1922; May 6–17 and June 13, 1923; July 11–17, 1923, in bush. Karioi, in beech forest, November 7, 1923; April 14, 1924. Raetihi Hill, 2,800 feet, November 30, 1923; April 8, 1924. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923; February 26, 1922.

189. AMPHINEURUS (NOTHORMOSIA) HARRISI Alexander.*

Amphineurus harrisi ALEXANDER, Ann. & Mag. Nat. Hist. IX 9 (1922) 304–305.

Type locality: Ohakune, October 10, 1921. Ohakune, November 8–24, 1922; May 10 and July 17, 1923. Karioi, in beech forest, November 7, 1923; April 14, 1924. Raetihi Hill, 2,800 feet, November 20–30, 1923. Ruapehu, beech zone, 3,000 to 4,000 feet, February 26, 1922; 4,000 to 4,500 feet, January 20, 1924.

190. AMPHINEURUS (NOTHORMOSIA) INSULSUS (Hutton).

Rhypholophus insulsus HUTTON, Trans. N. Z. Inst. 34 (1900) 188.

Spring and fall, in the mountains persisting into the summer; probably double brooded. Ohakune, October 1–27 and November 3–28, 1921; December 2, 1922; December 13–23, 1921; May 10, 1923. Karioi, in beech forest, November 7, 1923; April 14, 1924. Raetihi Hill, 2,800 feet, November 20–30, 1923; April 8, 1924. Ruapehu, beech zone, 3,000 to 4,000 feet, January 12, 1923.

191. AMPHINEURUS (NOTHORMOSIA) NOTHOFAGI Alexander.*

Amphineurus nothofagi ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 76.

Type locality: Karioi, in beech forest, April 14, 1924.

192. AMPHINEURUS (NOTHORMOSIA) PATRUELIS Alexander.*

Amphineurus (*Nothormosia*) *patruelis* ALEXANDER, Ann. & Mag. Nat. Hist. IX 16 (1925) 78.

Ohakune, October 10–15, 1921; November 8–14 and December 4, 1922.

ILLUSTRATION

TEXT FIG. 1. Sketch map indicating the limits of Ohakune district and Tongariro Park, North Island, New Zealand (1908).

SEX STUDIES ON PHILIPPINE FROGS AND TOADS, I

MALE INTERSEXUALITY IN RANA VITTIGERA WIEGMANN [1]

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TWO PLATES

Intersexuality in the frogs, toads, and salamanders has been the subject of numerous researches, the most comprehensive of which are those of Witchi (1921) and Crew (1921). By arranging sex abnormalities in frogs and toads as reported by various investigators in such a way that the first case in the list is that approximating a normal female and the last approaching a typical male, Crew (1921) concludes that an individual which at one time possesses characteristics of a female may transform into an individual with male sex equipment. This conclusion was supported by a completely transformed individual, formerly a female, which functioned as a male and fertilized the eggs of a normal female. All offspring of this mating that developed far enough to allow sex identification were females. Similarly striking observations were reported by Guyenot and Ponse (1923) on toads. Testes transplanted autoplastically or homoplastically, subcutaneously or intraperitoneally, into castrated males, transform, after a retention of eight to twelve months, into an ovotestis with a predominance of oögenesis. The toads, however, retained their normal male secondary sex characters. Champy (1921) found that intensively fed male tritons began to show external characters of the female. One of these, whose previous history as a male was known, when finally killed was found to have its testes replaced by an immature ovary containing young oöcytes.

Abnormal sexuality is a rather frequent occurrence among Philippine frogs, a fact well known to persons who have to obtain frog material for laboratory work. This paper describes

[1] This investigation has been aided by a grant from the Committee on Sex Research of the National Research Council of America. The grant has been obtained through the kindness of Prof. F. R. Lillie to whom the writer makes grateful acknowledgment for his constant interest in the work.

the commonest sex abnormality and attempts to explain its probable significance. The material used is the common frog, *Rana vittigera* Wiegmann, obtained from the grassy regions on the south shore of Laguna de Bay, Luzon. The other source of frogs used in our laboratory is Tinajeros, a village about 8 kilometers north of Manila. Since no sexual abnormalities are encountered among animals from the latter place and since the greater percentage of those collected from the former place show sexual irregularity in one way or another, it is thought that there may be a regional or racial difference in the sex constitution of these frogs.

For this work, all frogs from a single catch showing external characters of maleness are separated from the animals showing external features of femaleness, and a count for sex-ratio is made. Externally male-looking individuals are dissected and the condition of the gonads and reproductive ducts recorded. Frogs showing any form of abnormality are preserved for further examination after the gonads are removed and fixed. Material is fixed in Bouin's fluid, sectioned, and then stained in either Mallory's triple stain, Delafield's hæmatoxylin or Heidenhein's iron alum hæmatoxylin.

OBSERVATIONS

This paper deals with one hundred ninety-one frogs exhibiting abnormal gonads. These all possess external characters of the male; namely, pigmented sides of the throat, swollen thumbs, and vocal sacs. They are small and measure 55 millimeters from the tip of the snout to the vent on the average, as against 85 millimeters, the average length of mature females. The majority of the gonads are testislike in shape; but some are slightly flattened and broad while others, instead of being smooth and cylindrical, are lobulated or slightly inflated. In all cases, however, the gonad approaches the external appearance of a testis more than that of an ovary. Unlike normal testes, they show externally masses of pigmented spots in many regions. In all of them, the Wolffian ducts are typically male and have slight enlargements just before joining the cloaca in the form of a seminal vesicle. The Müllerian ducts, on the other hand, are larger than the ordinary vestigial oviduct of the male. Although convoluted, they do not attain the size of the oviducts of the normal female. It may be said that the Müllerian ducts of these intersexual males are half-way between those of normal males

and normal females. It has not been ascertained whether they have openings into the cloaca and from the cœlom or not.

Histologic examination shows the gonads to be ovotestes in which the testicular and the ovarian portions are not delimited from each other. The great majority of the seminiferous tubules are in active spermatogenesis, and they exhibit all stages of multiplication, maturation, and spermiogenesis. Mature spermatozoa are invariably present. The tubules are in close juxtaposition with each other, so that in the majority of cases the intertubular regions are either narrow or wanting. The interstices include for the most part ordinary connective-tissue cells, leucocytes, and pigmented cells. The last two named elements are rarely, if ever, encountered in normal frog testes.

Oögonia of different sizes are found in groups of various number, many of which, without any question, are located inside the seminiferous tubules. These oögonia-containing tubules can be divided conveniently into the following types, as seen in sections: (1) Tubules containing developing male germ cells for the most part with an admixture of few small oögonia which are attached to the walls of the seminiferous tubules. These oögonia are five to fifteen times as large as the spermatogonia and can be easily distinguished by their large and prominent germinal vesicles. They are, without any question, within the seminiferous tubules. (2) Tubules containing oögonia of medium size, free in the lumen or still attached to the tubular wall, in addition to male germ elements undergoing multiplication, maturation, and spermiogenesis. (3) Tubules containing large oögonia and a few or many mature spermatozoa. (4) Tubules containing nothing but oögonia of large size. After the oögonia have attained a large size, only two or three are encountered in a tubular section exerting a certain amount of pressure on each other such that they depart from the usual spherical shape. At this stage, also, it is often hard to figure out whether they are within or outside the seminiferous tubules.

DESCRIPTION OF A FEW CASES

Case 113.—Animal small, length from tip of snout to vent 56 millimeters; thumbs large but not much swollen; sides of throat darkly pigmented as in typical male. The gonads externally are symmetrical, oblong, narrow, 7 millimeters long and 1.2 millimeters wide. They show pigmented spots all over the surface, vasa efferentia present, seminal vesicles prominent; Mülle-

rian ducts small but slightly convoluted, joining the seminal vesicle before this enters the cloaca.

Histologic examination shows the gonads to be ovotestes in which the testicular portion is greater than the ovarian. The seminal tubules are in active spermatogenesis, showing all stages of multiplication, growth, maturation, and spermiogenesis. A few ova are large, but the greatest number are small. These are very young ova, many of which are attached to the walls of the seminiferous tubules (Plate 1, fig. 1). These ova are in no way different from young ova of a normal ovary, and they can easily be distinguished from the spermatogonia by their much larger size, by the greater amount of cytoplasmic materials, and by the large germinal vesicle. When a seminal tubule incloses these ova, both the female and the male germ elements appear normal and healthy.

Case 126.—Animal small, measuring 59 millimeters from the vent to the tip of the snout. External secondary sex characters are those of a typical male; the thumbs are swollen, the sides of the throat are pigmented, and vocal sacs are present. The gonads, externally, are alike and in no way different from normal testes except for the presence of a few pigment spots scattered on the surface. Vasa efferentia are present, and the ureters are enlarged before joining the cloaca to form a seminal vesicle. The Müllerian ducts approach the typical threadlike appearance of a male vestigial oviduct, although they show slight sinuosity.

Microscopic study of the gonads shows that they are ovotestes. The greatest part of each gonad is testicular, composed of closely set seminiferous tubules with hardly any intertubular region between them. Male germ elements are in processes of multiplication, maturation, and spermiogenesis, although mature spermatozoa may be absent in some tubular sections.

In these gonads there are only a few ova which are located near the hilum, at the center and on the surface of the gonad. By far the greatest number of these are young and small, found inside, and oftentimes attached to the walls, of seminiferous tubules (Plate 1, fig. 2). These have large clear germinal vesicles with one or several deeply staining nucleoli. The germinal vesicle is too large for the amount of cytoplasm. In these gonads the pigment cells are confined in certain basement membranes of the tubules. No pigment cells and no leucocytes are encountered around the ova.

Case 331.—Animal small; length from tip of snout to vent only 50 millimeters; thumbs swollen, typically malelike; sides of throat heavily pigmented, typical of a male in the breeding season. Gonads symmetrical, testislike externally, cylindrical, 10 millimeters long and 2 millimeters wide, with dark spots all around; vas efferens normal; seminal vesicle expanded; Müllerian ducts small, although convoluted and larger than those of a normal male, with a somewhat expanded posterior portion.

Longitudinal sections show the gonads to be ovotestes, in which the ovarian is greater than the testicular portion. There is no line of demarcation between the testicular and the ovarian portion. The testicular part includes seminiferous tubules with germ cells in all stages of spermatogenesis. The ovarian portion consists of ova of all sizes scattered throughout the gonad. Most of these are large and apparently in good health. Although these may be invested with a layer of pigment cells, they show no sign of degenerative changes. A few small ova are distinctly seen inside the tubules among male germ cells.

Case 336.—Animal small, measuring only 56 millimeters from the vent to the tip of the snout. The external characters are those of a typical male; sides of throat pigmented, thumbs swollen, and vocal sacs present. The gonads are elongated, flattened, with highly lobulated lateral edges and with dark spots all around. They measure 9 millimeters long and 2.7 millimeters wide. Although wide, they are thick and heavy-looking, unlike a typical young ovary which is saclike, thin, light, and transparent. Vasa efferentia present, the ureters enlarged at the base forming a seminal vesicle. The Müllerian ducts are large and convoluted, especially at the basal part. The ureter and the Müllerian duct join each other before entering the cloaca.

In this animal, the gonads are ovotestes in which the ovarian and testicular elements are found in practically the same amounts (Plate 2, fig. 18). The testicular portion is composed of closely set normal seminiferous tubules with elements in active spermatogenesis. Mature spermatozoa are found in practically all of them. The ova vary in size. Some are large and show signs of degenerative changes, such as vacuolation and liquefaction of the cytoplasm. Some are medium sized and normal. The greatest number, however, are small, young, and spherical, and without any question, within the seminiferous tubules. The young ova are found everywhere, near the point of attachment

of the ovotestes, at the center, and at the periphery. Pigment cells and leucocytes are found around the large old degenerating ova, but they are never found around the small ones.

Case 340.—Animal small, measuring 54 millimeters from the tip of the snout to the vent. Secondary sex characters are typical male; the sides of the throat are pigmented, the thumbs are swollen, and vocal sacs are present. The right gonad is cylindrical, 9 millimeters long and 2 millimeters in diameter. The left gonad is also cylindrical, but it has an enlarged inflated portion about 3.5 millimeters in diameter which has a thin wall. In both cases the outer surface of the gonad shows slight tuberculations. Vasa efferentia are present on both sides, while the seminal vesicles are small and the Müllerian ducts are prominent and coiled, although not attaining the large size of those of the female (Plate 1, fig. 4).

The right gonad is an ovotestis with the testicular portion greater than the ovarian. The seminiferous tubules are normal-looking and contain all stages of multiplication, maturation, and spermiogenesis. The ova are mostly large, and their exact relation with the seminiferous tubules is hard to determine. The smaller ova are normal-looking. The largest ova, however, are in various stages of disintegration. The first indication of this is the appearance of very numerous fine granules of unknown character in the cytoplasm. These granules stain very dark with hæmatoxylin and mav be scattered throughout the cytoplasm or may appear in large oval or elongated masses. The cytoplasm then begins to undcrgo vacuolation and liquefaction until the original position of the ova becomes a space now occupied by many small multinucleated leucocytes.

The left gonad is also an ovotestis. The unexpanded portions appear histologically similar to the right gonad. Although here the large ova are disintegrating, numerous small young ova are being proliferated from the walls of the seminiferous tubules intermingled with normal male germ elements.

The enlarged portion of this ovotestis shows that its inflated condition is due to the presence of one, two, or several "giant" tubules at the center, with enormous cavities occupying as much as two-thirds of the entire cross-section (Plate 2, fig. 5). These giant tubules may extend to the periphery of the ovotestis or they may be surrounded by small seminiferous tubules. The large lumina of the giant tubules are occupied by numerous

abnormally shaped spermatozoa scattered among granules mentioned above, leucocytes, and débris. The spermatocysts on the germinal epithelium of these giant tubules are loosely aggregated and much broken, especially at their distal sides, and the germ cells are in the process of disintegration and liquefaction. This condition is not in evidence in the germinal epithelium of the small, normal tubules. In addition to the male germ elements, small and apparently healthy ova are attached to the walls of the giant and small tubules.

Case 341.—Animal small, measuring 58 millimeters from the tip of the snout to the vent. Externally it possesses all the characters of the male; the sides of throat are pigmented, the thumbs are swollen, and vocal sacs are present. The right gonad is testislike in shape, more or less flattened. It measures 8 millimeters long and 2.1 millimeters wide and shows slight indentations on its lateral edge. The left gonad is 9 millimeters long and 2.2 millimeters wide and possesses deeper indentations. Vasa-efferential ducts are present on both sides; the seminal vesicle is not prominent; Müllerian ducts are coiled but much smaller than the oviduct of a normal female. The latter meet the ureters halfway between the posterior tip of the kidneys and the cloaca, so that they have a relatively long common tube (Plate 1, fig. 3).

Histologically, the right gonad is an ovotestis in which the testicular portion is much greater than the ovarian. The testicular portion is composed of seminiferous tubules of various sizes filled with male elements in all stages of spermatogenesis. Mature spermatozoa are invariably found inside these tubules. A few tubules are full of débris which is presumably the product of germinal disintegration. The female elements are represented by ova of various dimensions located in various regions of the ovotestis. Those at the middle of the gonad are large and show traces of destruction, while those situated at or near the periphery are small and normal-looking. Many of the latter are arranged in groups of four to ten and are distinctly seen located inside the tubules among male germ cells.

The left gonad shows almost a similar histologic condition, although here most of the ova are large (Plate 2, fig. 6). Also in this gonad more degenerate tubules full of débris and other products of male germ-cell disintegration are found. Many pigment cells and leucocytes are seen in the intertubular regions; they are especially abundant around large degenerating ova.

DISCUSSION

For the present it is very difficult to state definitely whether these ovotestes are normal in these frogs or these gonads are in a process of transformation from one sex to another. More-extended observation and experimental breeding are necessary to establish a definite conclusion.

These frogs fall under Division II, Group B, according to the classification adopted by Crew (1921). As numerous animals of this particular group come under our observation, we have a better chance to study the histologic conditions of the ovotestes. In our material the ovotestes may or may not be symmetrical. Although the two may depart to some extent from each other in size and shape, the proportionate amount of ovarian and testicular tissues found seems to be the same, so that if these gonads are in a state of transformation from one sex to another, the process must have been initiated simultaneously in the two gonads. The same can be said in general of the reproductive ducts. In practically all cases under observation, the ducts are more or less symmetrical.

Histologic studies of the ovotestes show that the male germ elements are invariably greater than the ovarian. The male germ elements are healthy and they appear to be the normal constituents of the gonads, while the ovarian tissues appear only here and there, scattered among male germ cells. This supposition is sustained by the fact that, while many of them are being produced and a great many have typical structures, many are in the process of disintegration. For a short time after being produced they retain the normal shape and structure of an ovum, but as they grow larger, they interfere not only with each other but also with other constituents of the gonads and thus lose their typical shape. The presence of leucocytes and pigments around degenerating ova may be also taken as a sign of the reaction of the organism to the existence of these atypical parts of the gonads.

Painstaking attempts fail to reveal a single point in the gonad where eggs are developed. On the contrary, young ova are seen given off from the walls of very many seminiferous tubules situated in various regions of the ovotestes. Crew (1921) mentions that ova may be found inside seminiferous tubules in European frogs and toads, but explains their presence in this position through an extrusion into the tubules from a primary position of the ova. Normally, however, only large ripe ova

are extruded, so that his supposition can be applied to the ovotestes under discussion only if all ova seen inside the tubules are large. In these ovotestes, small healthy young ova are found inside the tubules which appear normal in all respects. Many of these are attached to the walls of the tubules. Plate 2, fig. 7, shows a small sector of a tubule of frog 115 under high magnification, illustrating beautifully the ova under consideration. These cannot possibly have arisen from large degenerate ova as the latter are easily distinguished from the normal as these become highly vacuolated and distorted in shape without undergoing any reduction in size. Sooner or later they liquefy and become absorbed.

The conditions as found in *Rana vittigera* thus differ very markedly from those in European frogs and toads. In the latter no healthy ovarian tissues have been found included within the structure of healthy spermatic tissues (Crew, 1921). Crew explained this condition by saying that when ovarian tissues are healthy, that is to say, when they have not undergone appreciable degenerative changes, no considerable growth on the part of the spermatic tissue takes place. In these ovotestes, however, healthy spermatic and ovarian tissues are seen side by side inclosed in a common seminiferous tubule, similar to the condition reported by Guyenot and Ponse (1923) in toads. Of the two tissues, the spermatic is the more developed, while the ovarian tissues are being formed in many places.

Our study in the normal sex ratio in the larval and adult stages of *Rana vittigera* is not quite completed. Data up to the time of this writing, however, show that in the adult stage, during breeding or off-breeding seasons, there is a great preponderance of female individuals over the male. In places where male intersexual individuals are not encountered, the adult sex ratio is approximately 1 male to 1.47 females. In places where they are met often, the adult sex ratio runs as high as 1 male to 2.04 females. It is probably worth while mentioning in this connection that at one time, March 13, 1927, 156 externally male-looking frogs were collected together with 319 females; and, of the former, all except 7 have ovotestes. In fact, there are times of the year when we experience difficulty in obtaining males with typical normal testes. Such being the case, it appears that either there is a greater mortality of normal males in these frogs or the normal males may have transformed into males with ovotestes.

In *Rana vittigera,* the females are much larger than the males. The animals under consideration are small individuals with all external characters of the males; with gonads approaching the testis in size, shape, and contents; and with genital ducts approximating those of the male rather than those of the female. If these animals were originally females whose ovaries have transformed into testes recently, the following should have been found: (1) Larger individuals with ovotestes; (2) many individuals with a much greater ovarian tissue than spermatic; (3) some ovotestes that approach the ovary in shape more than the testis; (4) some ovotestes not connected with the kidney by the vas efferens; (5) some individuals with much better developed Müllerian ducts, with distinct openings to the cloaca and abdominal cavity. None of these, however, has been encountered.

If these individuals were originally females whose ovaries have started to transform into testes very early, it must be expected that in these ovotestes few or no young developing ova should have been found and that all ova should have been degenerate or degenerating as the gonads have transformed almost completely into testes. In our material, however, although mature spermatozoa are present everywhere, and the gonads are completely or almost completely testislike, the majority of the ova are either young and small or normal and large. Degenerating ova are relatively few, and these are not found in all ovotestes. It is also to be expected that if the transformation of ovary to testis has occurred very early, at least some Müllerian ducts should have been found showing a purely vestigial condition; that is, as fine straight strands of tissue as in normal males.

Both Witschi (1921) and Crew (1921) concluded in their work on intersexuality in frogs that there is a parallelism between the change in the development of the gonads and the change in somatic sex characters. The change in the somatic characters, however, takes place later than the change in gonadic contents (Lipschütz, 1924). Now in these frogs, all individuals show practically all external and internal somatic male characters, even if there is a preponderance of ovarian tissues (case 331) or when the ovarian and spermatic tissues are present in practically equal amounts (case 336). This goes to show that here the spermatic tissues have been in existence in the gonad much longer than the ovarian, and that the latter, although present in a greater amount in some specimens, presumably has not had sufficient time to cause the change in the somatic sex characters of the animal.

Case 340 may be considered as showing a process by which a solid structure of the testis may transform into a rather expanded thin-walled structure approximating that of an ovary. This process may have been initiated by the widening of the lumen of individual tubules or by the degeneration of certain tubules at the center of the testis so that their contents come to lie in a single large tubule. The end result in both cases, however, is the same where we find a giant tubule with an enormous lumen partly occupied by many degenerating male germ elements. Attached to the walls are still other male germ elements in the process of disintegration, while here and there, not far from the walls, we find healthy young ova.

The result of the findings of normal sex ratio in the adult stage of this particular group of frogs, the result of gross morphologic studies, and the result of the histologic study of their ovotestes suggest that, if these frogs are in a stage of sex-reversal, the course of transformation is from a male to a female, similar to what has been reported by Champy (1922) in *Triton alpestris* Laur. Of course, the previous history of these animals is not known, and more systematic and thorough breeding experiments are being done to test the validity of this assertion.

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ILLUSTRATIONS

[Drawings by H. A. Roxas.]

PLATE 1

FIG. 1. Camera lucida drawing of a cross section of a seminiferous tubule of frog 113, showing male and female germ elements. E. Leitz 15 × 16 mm.

2. Camera lucida drawing of a cross section of a tubule of frog 126, showing immature ova among healthy male germ cells. E. Leitz 15 × 16 mm.

3. Diagram of the urinogenital system of frog 341; × 2. *m*, Müllerian duct; *fb*, fat body; *ot*, ovotestis; *ve*, vas efferens; *k*, kidney; *sv*, seminal vesicle; *v*, cloaca.

4. Diagram of the urinogenital system of frog 340; × 2. Abbreviations as for fig. 3.

PLATE 2

FIG. 1. Cross section of the inflated portion of left gonad of frog 340, showing three "giant" tubules. Notice the degenerating sperms at the center of these tubules and the atypical spermatocyst of the germinal epithelium. Dissecting microscope 2 × a_0.

2. Camera lucida drawing of a portion of left ovotestis of frog 341, showing large ova among spermatozoa. E. Leitz 15 × 16 mm.

3. Camera lucida drawing of a portion of a tubule of frog 115, showing ova of different dimensions still attached to the wall of the seminiferous tubule. E. Leitz 15 × 4 mm.

4. A whole longitudinal section of the right ovotestis of frog 336, showing relative amounts of ovarian and spermatic tissues. Dissecting microscope 2 × a_0.

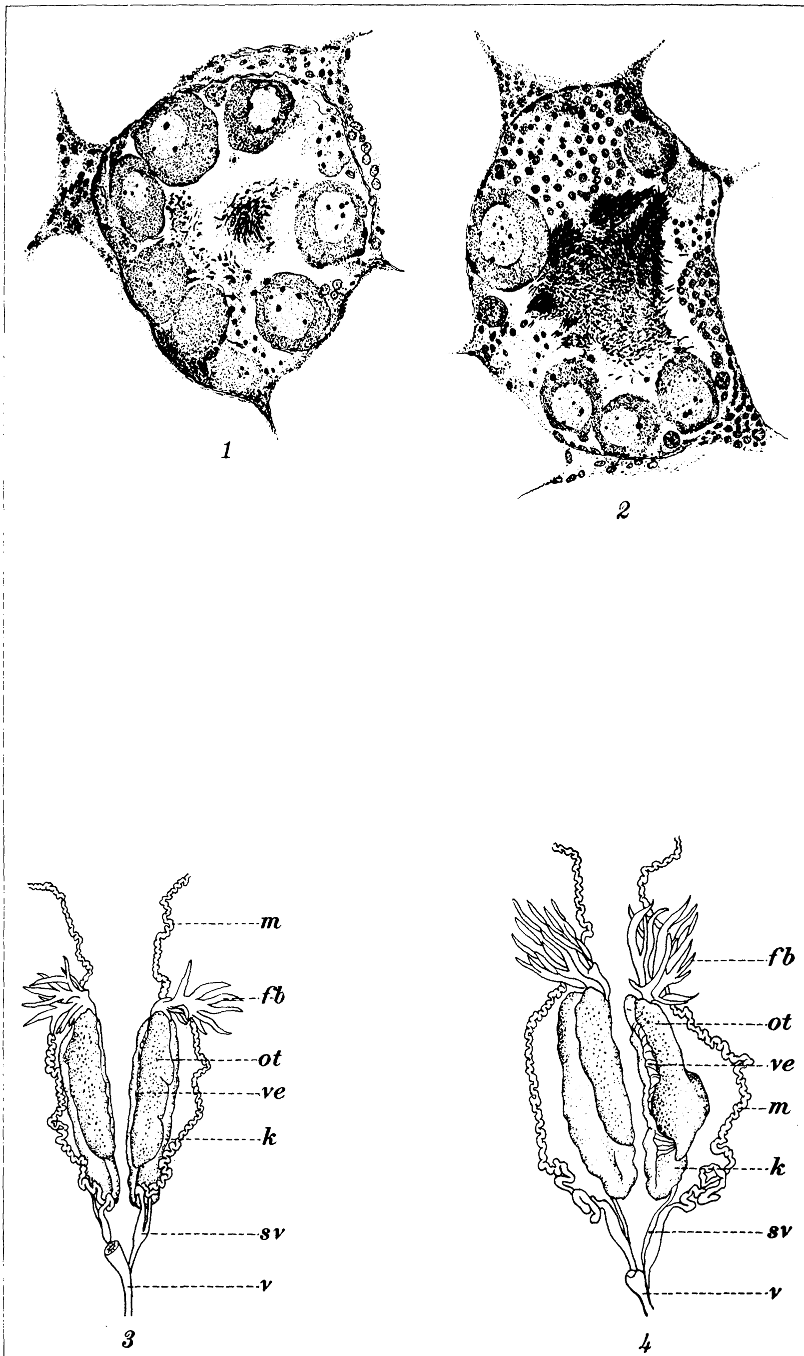
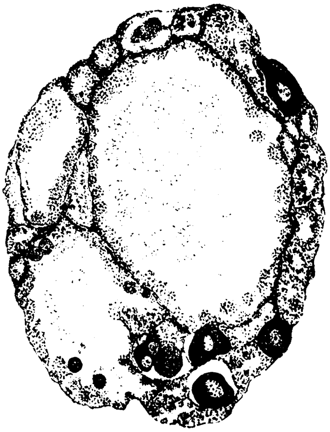


PLATE 1.



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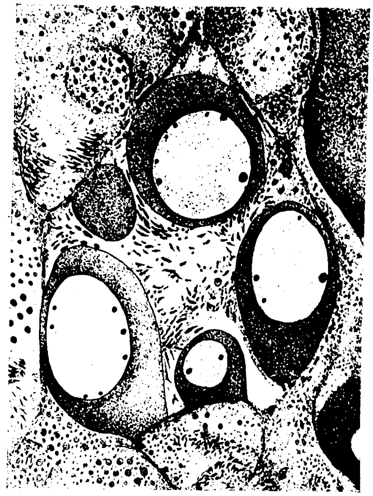

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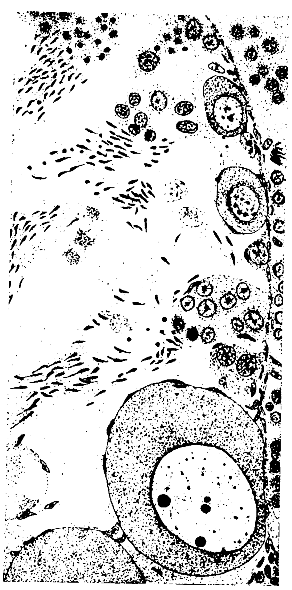

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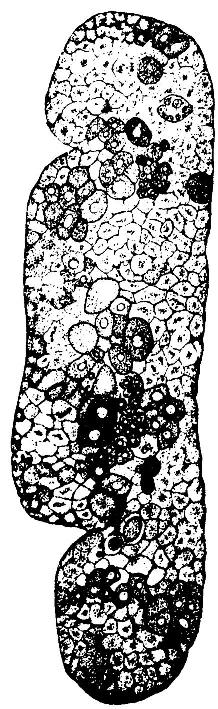

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PLATE 2.

SOME RELATIONS OF MAINTAINED TEMPERATURES TO GERMINATION AND THE EARLY GROWTH OF WHEAT IN NUTRIENT SOLUTIONS[1]

By W. F. Gericke

Of the University of California, Berkeley

TWO TEXT FIGURES

INTRODUCTION

In the autumn of 1918, the Committee on the Salt Requirements of Certain Agricultural Plants, appointed by the United States National Research Council, inaugurated a coöperative study of the growth of wheat plants in nutrient solution.(4) This prospective coöperation was to involve comparative experimental tests with a large number of nutrient solutions, the solutions differing according to a regular scheme. For a beginning several somewhat arbitrarily selected developmental phases of the wheat plant were to be studied. It was realized that a nutrient solution might be well suited for good growth during one phase of the plant's development and not so for another phase. It was also realized that a given nutrient solution may give good growth under one climatic complex and not under another, even though the second climatic complex might be well suited for growth with another nutrient solution. Briefly stated, it was planned to test different nutrient solutions under different climatic complexes.

The investigation here reported was carried out as a part of that general plan. It constituted a study of the growth of Marquis spring wheat in the germination phase, beginning with the exposure of the seed to the culture solution and continuing about five days, about as long as a wheat seedling under otherwise good conditions can maintain health in the absence of light. All tests were carried out in darkness, and seven different maintained temperatures were employed, each tested with one hundred twenty-six different nutrient solutions of the

[1] Botanical contribution from the Johns Hopkins University, No. 86.

3-salt type and also with distilled water. There were altogether 7 times 126, or 882, environmental complexes, and the series of tests was once repeated for all but the lowest temperature employed; 1,638 tests were carried out.

As it turned out, all the salt solutions used gave notably better growth than distilled water did, for all temperatures excepting the very lowest, with which the solutions and distilled water agreed on the whole in giving very little growth; but the different influences exerted by the different salt solutions for any maintained temperature were so variable, as appeared when the two tests of each solution were finally brought together and all solutions were compared for each temperature, that no clear and consistent relations could be discovered, from these experimental data, between growth vigor and solution composition. This is undoubtedly due to the fact that the solutions used were very dilute; if they had been of sufficiently higher concentration a clear series of relations between growth and solution composition for each temperature tested would probably have been evident. Since the numerical data secured were, therefore, not suited to a comparative study of salt influence the growth values were averaged for all solutions, for each temperature tested, and special attention was given to the very clear and consistent growth-temperature relations thus brought out. These temperature relations are the primary subject of the present publication.

The experimentation was performed in the Laboratory of Plant Physiology of the Johns Hopkins University, with financial aid from the Natioanl Research Council. The appreciative thanks of the writer are due to Prof. Burton E. Livingston for the facilities of his laboratory, for helpful advice in the experimentation, and for criticism of this paper.

EXPERIMENTATION

THE SOLUTIONS USED

The nutrient solutions used followed the plan above referred to. They are based on the scheme suggested by Livingston and Tottingham,(8) following the general outlines worked out by Schreiner and Skinner,(9) Tottingham,(11) Shive,(10) and other writers. The Livingston-Tottingham scheme embraces six types of solutions, each characterized by the three main salts employed, as follows:

Type I.	Type II.	Type III.
KH_2PO_4	K_2SO_4	KNO_3
$Ca(NO_3)_2$	$Ca(NO_3)_2$	$Ca(H_2PO_4)_2$
$MgSO_4$	$Mg(H_2PO_4)_2$	$MgSO_4$

Type IV.	Type V.	Type VI.
K_2SO_4	KNO_3	KH_2PO_4
$Ca(H_2PO_4)_2$	$CaSO_4$	$CaSO_4$
$Mg(NO_3)_2$	$Mg(H_2PO_4)_2$	$Mg(NO_3)_2$

Twenty-one nutrient solutions were employed in this study for each of the six 3-salt combinations, representing as many sets of salt proportions for each solution type. All told, there were one hundred twenty-six nutrient solutions. The solutions were approximately alike as to their total osmotic concentration or osmotic value, equivalent to 0.1 of an atmosphere of osmotic pressure. Each type of solution varied, however, in a systematic manner, as to the fraction of the total concentration any one of the constituent salts supplied. The unit employed in the calculation was one-eighth of the total concentration. In no case could any given salt supply less than one-eighth or more than six-eighths of the total salt concentration and it might supply any fraction of the total, from one-eighth to six-eighths. The Schreiner-Skinner triangle method of notation was employed, as developed in the plan. Table 1 shows the twenty-one salts for each solution type. The solutions were prepared from Baker Analyzed Salts and distilled water. Each one had, as has been noted, an osmotic value of about 0.1 atmosphere.

THE CULTURES AND THEIR TREATMENT

Although the wheat seed used was of a pure-line strain and although all grains were selected by hand and eye, considerable variation was encountered. However, it is probable that the selected grains exhibited much less variability (due to differences in internal conditions) than is generally shown by agricultural seed wheat of the Marquis variety.

Glass tumblers (capacity, about 300 cubic centimeters) were employed as culture vessels; each had a tightly stretched cover of thoroughly washed mosquito netting (of cotton thread, with open meshes about 2 millimeters square) tightly sealed to the outside of the tumbler wall by means of paraffin. Each of these net-covered tumblers was filled with the proper solution (or with distilled water), and twenty-five selected seeds were dis-

TABLE 1.—*Molecular proportions or fractions of total concentrations of constituent salts in nutrient solutions, the unit being one-eighth of the total concentration.*

Solution symbol.	Molecular proportions (eighths of total concentration).		
	Potassium salt.	Calcium salt.	Magnesium salt.
R1S1	1	1	6
R1S2	1	2	5
R1S3	1	3	4
R1S4	1	4	3
R1S5	1	5	2
R1S6	1	6	1
R2S1	2	1	5
R2S2	2	2	4
R2S3	2	3	3
R2S4	2	4	2
R2S5	2	5	1
R3S1	3	1	4
R3S2	3	2	3
R3S3	3	3	2
R3S4	3	4	1
R4S1	4	1	3
R4S2	4	2	2
R4S3	4	3	1
R5S1	5	1	2
R5S2	5	2	1
R6S1	6	1	1

tributed uniformly over the netting, the area of which was about 38 square centimeters. All seeds were in contact with the liquid, but none was submerged. Several methods of supporting the seeds and seedlings were tested in the preliminary part of the study, and this one proved best.

Each series of cultures involved only one type of solution but included twenty-one different solutions, each of these being represented by seven cultures. Each set of seven like cultures was distributed throughout the seven different temperatures tested, so that a single series comprised twenty-one solution cultures. All of the twenty-one nutrient solutions of any one solution type were thus simultaneously tested for each of the seven temperatures, and there were one hundred forty-seven solution cultures in each series. Each nutrient solution was renewed after each period of about twenty-four hours, for four renewals, the cultures being discontinued on the fifth day.

In a similar way tests were conducted on the germination of this wheat with distilled water for each of the temperatures and for equal periods of time as stated for the nutrient solutions.

The battery of chambers for temperature control at the Laboratory of Plant Physiology of the Johns Hopkins University, which has been described in its essentials by Livingston and Fawcett,(6) was used for this investigation. The seven temperatures employed were 13, 17, 21, 25, 28, 31, and 35° C. Variations from these values were never as great as 1°. The air humidity approached that of saturation for the given temperature in each chamber. Light was excluded as has been said.

Renewal of the solutions did not always occur at exactly 24-hour intervals, and the total length of the culture period was always less than five days, usually about one hundred ten hours. Variation from the time schedule was not great in any case, however, and all cultures of any series (twenty-one solutions of a single type, with each of the seven temperatures used) had the same time periods between renewals and the same total period. About eighty-six hours after the beginning of each series each shoot 1 centimeter long or longer was measured and record was made showing the number of seedlings in each culture that were 1, 2, 3, etc., centimeters high. All shoots were again measured after about one hundred ten hours, when the cultures were discontinued. To avoid much disturbance of the plantlets, the earlier measurements were correct only to a precision of about 1 centimeter, but the final measurements were more carefully made, to a precision of 1 millimeter, each seedling being removed from the solution at that time. These two measurements for each culture may be termed the "first" and the "second," occurring after about eighty-six and one hundred ten hours, respectively. The numerical results obtained for each culture were as follows: 1, Number of seedlings with shoots 1 centimeter or more high after about eighty-six hours; 2, approximate total shoot length (of all seedlings) after about eighty-six hours; 3, number of seeds germinated after about one hundred ten hours; 4, total shoot length (of all seedlings) after about one hundred ten hours; 5, total shoot elongation for the last twenty-four hours (obtained by subtracting 2 from 4, above).

The number of seeds germinated at the end of the whole period (3, above) may be taken to represent the seed viability for any culture; if this number is multiplied by 4 the product

represents the percentage of germination, since each culture had twenty-five seeds.

Each shoot-length total (2 and 4, above), divided by the corresponding number of seedlings measured, gives the average length of shoot for the seeds that had germinated in the culture in question. This quotient represents, in each case, the average shoot elongation per seed, omitting the seeds that failed to germinate. Finally, since the time periods were not exactly the same for all series, the quotient just mentioned was divided by the number of hours elapsed since the starting of the culture in question, thus giving the mean hourly rate of shoot elongation for the given culture. Subtracting the total shoot length for the shorter period (2, above) from the corresponding value for the longer period (4, above) gives a number representing the total shoot elongation for the last portion (about twenty-four hours) of the whole culture period (5, above). From this was obtained, as above, the mean hourly rate of elongation for the last portion of the period.

SALT RELATIONS

Of the forty-two tables of data that were obtained, only a list of the apparently best and apparently poorest solutions of each type, for the entire period of about one hundred ten hours, is here given for each temperature employed (Table 2). Data for only six temperatures are shown, those for the lowest temperature tested (13°) being omitted because growth was so low in that case as to render precision of measurement very low. In the category of apparently best solutions are included, for each type and temperature, only those that agreed for the two tests in giving mean hourly growth rates above the average for the series in which they occurred, and that showed differences not greater than 0.11 millimeter between the corresponding rates for the two tests. In the category of the apparently poorest are included, for each type and temperature, only those solutions that gave the lowest four hourly growth rates for their respective series for both tests, and that showed differences not greater than 0.11 millimeter between the corresponding rates for the two tests.

The data given in Table 2 were plotted on triangular diagrams in the usual manner, with a diagram for each temperature. In every case the solutions of either category (best or poorest) occupy scattered locations on the diagram, which makes it impossible to derive clear and consistent evidence regarding the salt relations. In order that any particular nutrient solu-

TABLE 2.—*Apparently best and apparently poorest solutions for shoot elongation for the entire 110-hour period, for each solution type, and for each maintained temperature employed.*

Solution type.	Temperature, 17°C.		Temperature, 21°C.		Temperature, 25°C.	
	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.
I	R4S3	R1S2	R3S1	R2S2	R1S4	R2S2
	R5S1	R1S3	R4S2	R3S3		
		R1S4		R3S4		
		R2S2		R4S3		
II	R4S3	R1S4	R1S3	R2S3		R4S3
	R5S2	R3S1	R4S1	R3S2		
			R5S2			
			R6S1			
III	R2S2	R1S3	R2S5		R2S4	R4S2
	R3S4	R4S3			R2S5	R6S1
	R5S1	R5S2				
IV	R5S1	R1S6	R1S3	R2S2	R1S2	R2S4
	R5S2	R2S1	R4S2	R2S3	R1S4	R5S2
		R2S3		R2S3	R1S5	
		R2S4		R5S2	R2S1	
		R3S2		R6S1	R2S2	
		R3S4				
V	R5S2		R1S3	R3S4	R1S4	R5S2
			R2S1		R4S2	
			R5S1			
VI	R3S4	R1S1	R5S1	R2 S3	R1S4	R1S5
	R4S3		R5S2	R2S4	R4S2	R1S6
	R5S1		R6S1	R3S2	R5S1	
	R6S1				R6S1	

Solution type.	Temperature, 28°C.		Temperature, 31°C.		Temperature, 35°C.	
	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.
I	R1S3		R5S2		R3S2	R1S1
	R1S4				R3S3	
	R3S2					
	R4S1					
	R4S2					
II	R1S2	R2S4	R1S3	R1S1	R2S5	R1S2
	R1S3	R2S5	R1S4	R4S3	R4S1	R3S1
	R1S4	R3S4	R1S5		R4S3	
	R2S1	R5S1	R2S1			
III	R1S4	R3S2	R1S1	R3S2	R1S5	R5S2
	R1S5	R5S2	R1S2	R4S2	R2S2	
	R2S1		R1S3	R4S3	R2S4	
	R2S2		R1S4	R6S1		
			R1S5			
			R3S3			

TABLE 2.—*Apparently best and apparently poorest solutions for shoot elongation for the entire 110-hour period, for each solution type, and for each maintained temperature employed*—Continued.

Solution type	Temperature, 28° C.		Temperature, 31° C.		Temperature, 35° C.	
	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.	Best solutions.	Poorest solutions.
IV	R1S4	R2S3	R1S1	R3S4	R1S3	-------
	R1S5	R5S2	R2S1	R5S1	R1S5	-------
	-------	-------	R2S5	-------	-------	-------
	-------	-------	R5S2	-------	-------	-------
V	R1S4	R6S1	R1S2	R5S2	R2S1	R1S5
	-------	-------	R1S3	-------	R2S2	-------
	-------	-------	R1S4	-------	R4S2	-------
	-------	-------	R2S1	-------	R5S2	-------
	-------	-------	R3S2	-------	-------	-------
	-------	-------	R4S2	-------	-------	-------
VI	R1S3	R1S5	R1S1	R2S1	R5S1	R1S6
	R3S4	-------	R1S3	R2S2	R5S2	-------
	R4S2	-------	R3S1	-------	R6S1	-------

tion might be properly designated as one of the "best" or "poorest," in relation to specific salt effects, it would be logically necessary that the solutions shown as adjacent to it on the diagram should also be correspondingly relatively good or bad, according to the manner in which these adjacent solutions differed in salt proportions from the given solution. This necessity is not met by any of the diagrams, and these results therefore fail to show any clear picture of the salt relations dealt with. Consequently these important physiological relations cannot be discussed on the basis of the data of this study. If there were actually different influences exerted on the plantlets by the several solutions tested, their effects were masked by other influences; such as, the inherent variability of the seeds employed.

It is to be remembered that the solutions here used were very dilute, their osmotic value being only about 0.1 atmosphere, and that the culture period was very short, not extending beyond what is often regarded as the phase of seed germination. As has been said, if a sufficiently higher concentration had been employed it is probable that pronounced salt relations would have been brought out, even for this short culture period. It also seems safe to suppose that these very dilute solutions would have shown consistent differences if the culture period had been sufficiently long, but the period could not have been much longer without making light a necessary condition, with all the experimental difficulties that are thus implied.

Several somewhat vague suggestions, with regard to salt relations, were secured from the study of the triangular diagrams here referred to, and some of them have subsequently led to what appear to be valuable and valid results, secured with longer periods and with light included in the environmental complex. These results are reserved for other publications, however, since they cannot be based on the experimental data of the study now being reported.

In the present study the solutions all agreed in producing much higher growth rates than did cultures with the same maintained temperatures but with distilled water as the culture medium. This point will be discussed below, after the temperature relations for all solutions taken together are presented.

TEMPERATURE RELATIONS OF SOLUTION CULTURES FOR THE ENTIRE 110-HOUR PERIOD

Temperature clearly exerted a marked and consistent influence on the rate of germination and early growth of these wheat seedlings, in spite of the inherent variability in the seeds used. In such a study as this it would be desirable to study the temperature relations for each solution tested and then to study the influence of temperature on the influence of solution composition; that is, to compare the temperature relations of good and poor solutions, etc. Such a treatment might result in a very complete analytical survey of the influence of all environmental conditions if it were warranted by the experimental data. Since, however, the data here brought forward are of such nature as to preclude, for the present, a thorough-going study of the salt relations for any temperature, it is best to resort to a more general and less analytical survey of the temperature relations here shown. Instead of attempting to compare temperature relations for the different solutions, we study the general temperature relations for all of the solutions tested taken together; that is, for the whole range of the one hundred forty-seven sets of solution conditions or salt proportions employed. This amounts to saying that, for the purposes of this survey of temperature relations, we treat all solutions as though they were physiologically alike and derive a single grand average growth rate for each of the seven temperatures tested.

Table 3 presents the mean growth rate for the entire period of about one hundred ten hours for each solution type in each of the two tests and for each temperature. In the last column are given the grand averages, a single value for each temper-

ature. The minimum and maximum mean growth rates are given, as well as the average for each set of twenty-one cultures. The three values (in hundredths of a millimeter per hour shoot growth, for periods ranging from one hundred eight to one hundred fourteen hours) are given consecutively, separated by colons, as follows, minimum : average : maximum. The average for the several pairs of like tests (excepting for the lowest temperature, for which only one test was made) are shown in the next to the last column of the table, and the grand average for each temperature is given in the last column as has been noted. The grand averages bring out very clearly the facts that the highest rates of shoot elongation were obtaind with the maintained temperatures 28° and 31° (the values being about alike), that temperatures 25° and 35° gave rates markedly lower than those for 28° and 31°, and that temperatures 21°, 17°, and 13° gave still lower rates, these being progressively lower with lower temperatures. These grand averages will receive more attention farther on in this paper.

TABLE 3.—*Average hourly rates of shoot elongation for the entire culture period of about one hundred ten hours for all solution cultures and for each maintained temperature tested.*

[The rates are expressed in terms of hundredths of a milimeter.]

Temperature.	Solution type.	Length of period.		Minimum, average, and maximum hourly rate.[a]		Average of first and second tests.	Grand average.
		First test.	Second test.	First test.	Second test.		
°C.		*Hrs.*	*Hrs.*	*0.10 mm.*	*0.10 mm.*	*0.10 mm.*	*0.10 mm.*
13	I	114	--------	04:06:07	--------	--------	7
	II	108	--------	04:07:10	--------	--------	
	III	110	--------	03:04:06	--------	--------	
	IV	112	--------	04:06:08	--------	--------	
	V	108	--------	06:09:13	--------	--------	
	VI	108	--------	04:06:07	--------	--------	
17	I	114	112	14:20:23	21:25:29	22	24
	II	108	110	19:24:30	13:19:22	22	
	III	110	112	20:28:35	16:23:27	26	
	IV	112	110	12:20:25	19:23:26	21	
	V	108	114	32:39:47	17:25:33	32	
	VI	108	110	16:21:26	20:25:30	23	
21	I	114	112	32:38:46	37:46:52	42	42
	II	108	110	33:41:47	27:33:39	37	
	III	110	112	40:48:53	22:34:42	41	
	IV	112	110	32:36:42	36:43:49	40	
	V	108	114	44:57:67	35:46:57	51	
	VI	108	110	33:44:70	22:42:52	43	

[a] The first value given is the minimum, the second is the average, and the last the maximum.

TABLE 3.—*Average hourly rates of shoot elongation for the entire culture period of about one hundred ten hours for all solution cultures and for each maintained temperature tested*—Continued.

Temperature.	Solution type.	Length of period. First test.	Length of period. Second test.	Minimum, average, and maximum hourly rate.[a] First test.	Minimum, average, and maximum hourly rate.[a] Second test.	Average of first and second tests.	Grand average.
°C.		*Hrs.*	*Hrs.*	*0.10 mm.*	*0.10 mm.*	*0.10 mm.*	*0.10 mm.*
25	I	114	112	43:50:61	48:57:66	55	55
	II	108	110	48:54:65	35:45:49	50	
	III	110	112	43:59:68	43:53:62	55	
	IV	112	110	48:53:62	41:54:60	54	
	V	108	114	50:67:79	44:57:67	62	
	VI	108	110	48:58:65	38:52:62	54	
28	I	114	112	52:64:73	55:68:78	66	66
	II	108	110	55:63:84	45:58:79	61	
	III	110	112	53:70:86	49:63:89	67	
	IV	112	110	52:64:94	47:67:84	66	
	V	108	114	61:74:98	55:67:78	71	
	VI	108	110	57:70:84	50:63:75	67	
31	I	114	112	50:64:71	63:70:77	67	66
	II	108	110	50:63-77	52:67:82	65	
	III	110	112	49:69:78	53:67:78	68	
	IV	112	110	54:68:78	52:68:83	68	
	V	108	114	47:66:76	46:64:77	65	
	VI	108	110	63:74:85	54:62:70	68	
35	I	114	112	38:53:70	47:61:70	57	53
	II	108	110	23:47:61	40:51:60	49	
	III	110	112	25:57:71	37:52:61	55	
	IV	112	110	47:60:78	37:51:64	56	
	V	108	114	36:49:59	34:52:67	51	
	VI	108	110	43:51:59	41:48:65	49	

[a] The first value given is the minimum, the second is the average, and the last the maximum.

TEMPERATURE RELATIONS OF THE DISTILLED-WATER CULTURES FOR THE ENTIRE PERIOD OF ABOUT ONE HUNDRED TEN HOURS

In the second column of Table 4 are given the average results of the tests with distilled water, and the remainder of this table summarizes the corresponding results from the solution cultures, the latter from Table 3. The growth rates for the distilled-water cultures show the same general temperature relations as those shown by the highest rates, the lowest rates, and the grand averages for the nutrient-solution cultures. In all cases the rates for 28° and 31° are the highest and are about alike, those for 25° and 35° are lower and about alike, while those for 21°, 17°, and 13° are progressively still lower.

TABLE 4.—*Summary of hourly rates of shoot elongation for distilled-water cultures and nutrient-solution cultures for the entire period of about one hundred ten hours and for each maintained temperature tested.*

[The rates are expressed in terms of hundredths of a millimeter.]

Temperature.	Average hourly rate, both tests combined when there were two tests.			
	Distilled-water cultures.	Nutrient-solution cultures.		
		Highest rate obtained.	Lowest rate obtained.	Grand average.
°C.	*0.01 mm.*	*0.01 mm.*	*0.01 mm.*	*0.01 mm.*
13	7	13	3	7
17	16	30	18	24
21	22	58	13	42
25	31	72	46	55
28	36	86	51	66
31	33	80	46	66
35	30	68	38	53

It is to be especially emphasized that the distilled-water value is markedly lower in every case, with the single exception of that for 13°, than is the corresponding highest rate or the corresponding grand average value from the nutrient-solution cultures. Furthermore, the distilled-water value is somewhat lower than even the lowest rate from the nutrient-solution cultures in all cases, excepting for 13°. It appears from these results that the cultures with distilled water generally gave mean rates about half as great as the corresponding rates obtained with nutrient solutions. With the lowest temperature tested (13°, which is much too low for good growth of these plants) the distilled-water cultures gave a rate just equal to the grand average for this temperature with nutrient solutions.

All of the solutions tested were of about the same osmotic value (equivalent to about 0.1 atmosphere of osmotic pressure), and consequently one of the main features by which all solutions agreed among themselves and yet differed from distilled water is with regard to osmotic value. They also differed from water, and agreed among themselves, in that they all contained the six kinds of inorganic atoms or atomic groups (potential ions) known to be needed in considerable amounts by plants in general, although they did not contain these atoms and groups in the same proportions. It is clear that the presence of a slight osmotic value due to the salts used, or the presence of small amounts of the essential atoms and atomic groups in the solu-

tions, greatly improved the water for the kind of plant and the growth phase here dealt with. The water used was from a Barnstead still. It has generally been found to be free from copper or other highly poisonous impurity. It was not specially studied in connection with this work.

To the conclusions thus far reached may now be added these, that all the solutions used were much better suited to the germination and growth of this wheat than was distilled water. It is safe to emphasize the point, already considered by Shive,(10) that distilled water is not at all suitable as a germination medium when solution cultures are being studied, unless sickly plantlets are required.

The unsuitability of distilled water for seed germination, etc., has been emphasized and discussed by several other authors.[2] The injurious effect here shown was very probably due to outward diffusion of substances from the seed and seedlings. This conclusion follows the discussions of True and Bartlett,(13) and of True,(12) based on somewhat similar experiments.

TEMPERATURE RELATIONS OF SOLUTION CULTURES FOR THE LAST TWENTY-FOUR HOURS OF THE CULTURE PERIOD AND FOR THE EARLIER PART OF THE PERIOD

It is to be realized that the data for the temperature relations for the entire culture period (Tables 3 and 4) refer to actual shoot elongation only in part, for shoot elongation had not yet begun in the earlier part of the period. In a very general way, the data for the last twenty-four hours may be regarded as referring primarily to seedling enlargement, while those for the earlier portion of the period may be considered as referring largely to the preliminary processes generally considered together as seed germination. Therefore, it is worth while to study the average growth rates, not only for the entire period but also for the last twenty-four hours of the period and for the preceding portion also. Tables 5 and 6 present summaries of the growth-temperature data for all solution cultures, for these two partial periods. It is clear that the average rates shown in Table 5 (last twenty-four hours) are in general much larger than the corresponding ones shown in Tables 3 and 4 and in Table 6. The notations of Tables 5 and 6 are self-explanatory.

[2] A résumé of the literature on the physiological properties of distilled water, up to the time of its publication, is given in the paper by B. E. Livingston et al.; (4) see also True and Bartlett.(13)

TABLE 5.—*Average hourly rates of shoot elongation for the last twenty-four hours of the culture period, for all solution cultures and for each maintained temperature tested.*

[The rates are expressed in terms of hundredths of a millimeter.]

Temperature.	Solution type.	Mean hourly rate. First tests.	Second tests.	Average, first and second tests.	Grand average.
°C.		*0.01 mm.*	*0.01 mm.*	*0.01 mm.*	*0.01 mm.*
13	I	27	----------	27	30
	II	31	----------	31	
	III	24	----------	24	
	IV	26	----------	26	
	V	40	----------	40	
	VI	27	----------	27	
17	I	72	84	78	82
	II	90	91	90	
	III	83	75	79	
	IV	75	----------	75	
	V	100	----------	100	
	VI	----------	87	87	
21	I	104	126	115	112
	II	126	110	118	
	III	101	96	99	
	IV	108	101	105	
	V	120	115	118	
	VI	104	123	114	
25	I	140	140	140	137
	II	135	137	136	
	III	138	124	131	
	IV	140	124	132	
	V	153	141	147	
	VI	130	138	134	
28	I	151	149	150	157
	II	158	158	158	
	III	160	156	158	
	IV	154	152	153	
	V	166	158	162	
	VI	162	160	161	
31	I	143	149	146	153
	II	148	165	152	
	III	156	140	148	
	IV	162	145	153	
	V	153	158	155	
	VI	165	156	161	
35	I	118	126	122	124
	II	121	137	129	
	III	123	118	121	
	IV	134	114	124	
	V	128	131	129	
	VI	121	121	121	

TABLE 6.—*Average hourly rates of shoot elongation for the first part (about eighty-six hours) of the culture period, for solution cultures and for each maintained temperature tested.*

[The rates are expressed in terms of hundredths of a millimeter.]

Temperature.	Solution type.	Mean hourly rate.			Grand average.
		First test.	Second test.	Average, first and second tests.	
°*C.*		*0.01 mm.*	*0.01 mm.*	*0.01 mm.*	*0.01 mm.*
17	I	7	9	8	9.5
	II	5	----------	5	
	III	12	9	11	
	IV	8	----------	8	
	V	16	----------	16	
	VI	9	----------	9	
21	I	20	23	22	23
	II	17	13	15	
	III	29	29	29	
	IV	18	23	21	
	V	33	23	28	
	VI	24	20	22	
25	I	30	33	32	32
	II	31	23	27	
	III	38	33	36	
	IV	31	33	32	
	V	38	32	35	
	VI	35	28	32	
28	I	41	46	44	40
	II	34	33	34	
	III	40	36	38	
	IV	38	40	39	
	V	44	40	42	
	VI	41	37	39	
31	I	40	47	44	42
	II	40	34	37	
	III	44	47	46	
	IV	43	44	44	
	V	38	37	38	
	VI	46	37	42	
35	I	35	41	38	31
	II	27	25	26	
	III	38	34	36	
	IV	36	32	34	
	V	26	27	27	
	VI	28	26	27	

The general temperature relations shown in Tables 3 and 4 are seen to hold also for Tables 5 and 6. The mean hourly rates given in the last table are, of course, much lower than the corresponding ones for the last twenty-four hours (Table 5) and

they are notably lower than those for the entire period (Tables 3 and 4). The next section will be devoted to a comparison of these three sets of growth-temperature data by means of graphs.

GRAPHS OF THE GROWTH-TEMPERATURE RELATIONS

The data of Tables 4, 5, and 6 are set forth graphically in fig. 1, which it will be noted includes a graph of the entire-period data for the distilled-water cultures. These graphs have been

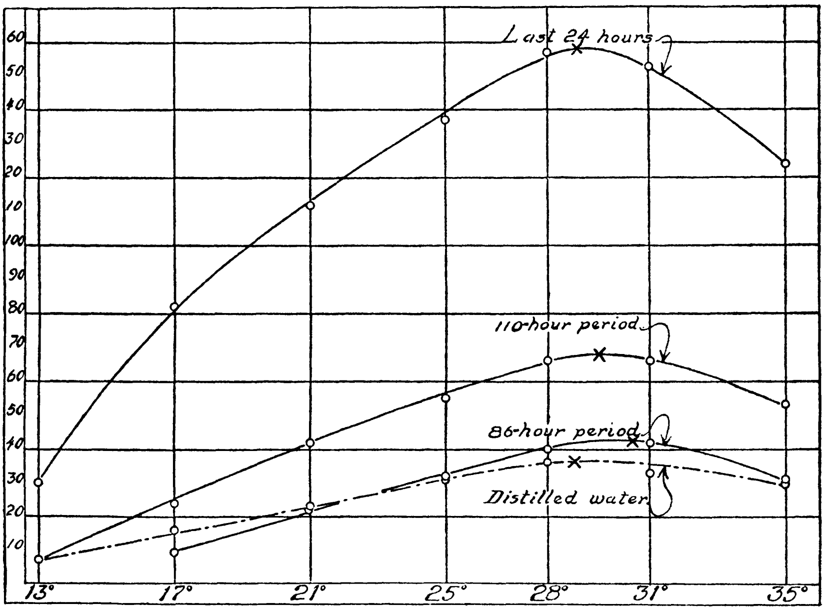

FIG. 1. Graphs showing the relation of maintained temperature to the mean hourly rates of shoot elongation in the solution cultures, for the entire culture period (about one hundred ten hours), for the last twenty-four hours of the period, and for the first part of the period (about eighty-six hours); and also for the distilled-water cultures for the entire period. Temperatures are shown by abscissas and growth rates by ordinates. Data are from Tables 3, 4, 5, and 6. An × on each graph indicates the approximate position of the maximum growth rate and the corresponding abscissa indicates the approximate position of optimal temperature on the thermometer scale.

subjected to only a very slight amount of smoothing and even that was hardly necessary; the ordinate values taken from the tables form remarkably smooth and consistent curves. As has been stated above, all three series of grand averages for the solution cultures (for the whole period, for the last twenty-four hours, and for the first part of the period) agree in showing the highest growth rates for maintained temperatures of 28° and 31°, and the values for these two temperatures are nearly alike in all three cases. The same is true for the averages from the

distilled-water cultures. From these observations, and from the graphs of fig. 1, it seems to be clear that the optimum temperature for the germination of these wheat seeds and for early shoot growth of the resulting seedlings in darkness lay between 28° and 31°, surely not above 31° nor below 28°. Assuming that the graphs are closely representative of the actual statistical data on which they are based, it appears from their curvatures that the optimum for the solution cultures was about 29° for the last twenty-four hours of the period, about 30.5° for the preceding part of the period (about eighty-six hours), and about 29.5° for the entire period. For the distilled-water cultures and for the entire period the optimum is shown as lower than in any other case, about 28.5°. Perhaps these differences are not significant and 29.5° may safely be taken as a very close approximation to the optimum from all four sets of data. Had the seedlings been allowed to develop farther, it is probable that the difference between the optimum for the early and for the later part of the period would have been of greater magnitude. Lehenbauer (3) has discussed an alteration of the optimum temperature as development proceeds in seedlings of maize.

An interesting point brought out by these graphs is that each curve is very nearly symmetrical about the vertical line that passes through its maximum. This does not appear to be generally true in growth and other biological processes; in many cases reported in the literature (see Lehenbauer, (3) just mentioned, for example; also Kanitz (2) and Fawcett (1)) the upward slope of this sort of graph is more gradual than the downward slope.

The average hourly growth rate for any temperature is seen to be very much greater for the last twenty-four hours of the period than for the entire period; and this, in turn, is notably greater than the rate for the first eighty-six hours. This must follow from the fact that the earlier portion of the experiment period was devoted to germination activities on the part of the seeds, while shoot elongation became prominent only after a considerable portion of the period had elapsed. The data for the last twenty-four hours really refer to young plantlets rather than to germinating seeds, as has been noted.

These graphs, like the data from which they are derived, fail to give any definite indication as to the minimum and the maximum temperature for germination and growth. With considerable more labor these two critical points might have been

determined approximately, but this study was not planned to deal with temperature maxima and minima.

In the preparation of wheat seedlings, from seeds like those used in this study, for solution culture and other experiments, it may be recommended that a maintained temperature between 29° and 30° be employed, if the most rapid shoot elongation in darkness is desired. If temperature is not maintained its fluctuation should not greatly exceed the range between 28° and 31°. It must of course be borne in mind that this recommendation is based on these particular tests. Such statements as this need to be carefully guarded, to avoid the possibility of a generalization being carried farther than is warranted by the facts in hand. Other temperature relations may perhaps be discovered for other lots of wheat seed and probably for other media than those here tried. It is especially worthy of note that these same sets of salts and salt proportions (or any one of these sets) might possibly exhibit significantly different temperature relations if longer test periods were employed or if the osmotic value of the solutions used were sufficiently higher than here dealt with. The present paper is calculated to go beyond what is really shown by the experimental results only in so far as interpolations have been made for temperatures not tested, in the graphs of fig. 1. The smooth form of the curves appears to warrant their use for interpolations.

TEMPERATURE COEFFICIENTS OF SHOOT ELONGATION

A very satisfactory method for picturing at least some important aspects of the temperature relations of any process is the method of temperature coefficients.[3] The temperature coefficient for a given process and for a given temperature interval is the quotient obtained by dividing the process rate for the higher temperature by that for the lower. The interval is conveniently taken as 10° C., and the coefficient is generally represented by the symbol Q_{10}.

The values for Q_{10} were obtained for shoot elongation in these seedlings, for all the 10° intervals available by whole degrees, and for the entire period and the two parts of it. From each solution graph of fig. 1 was determined the approximate hourly rate for each temperature from 13° to 35°, by whole degrees. This rate for the 24-hour period and for 13° is 0.29 millimeters

[3] For literature on this subject see Livingston and Shreve (7) and the references there given; see also Kanitz, Lehenbauer, and Fawcett, cited above.

and that for the same period and for 23° is 1.30 millimeters, so that Q_{10} (13°–23°) is 1.30 divided by 0.29, which is 4.5. The values of Q_{10} for all the 10° ranges of the three test periods (the last twenty-four hours, the preceding eighty-six hours, and the entire one hundred ten hours) are given, by whole numbers of degrees, in Table 7, which is self-explanatory.

TABLE 7.—*Ten-degree temperature coefficients* (Q_{10}) *for shoot elongation for the last twenty-four hours of culture period, for the entire period, and for the first eighty-six hours.*

Temperature interval.	For last 24 hours.			For entire period (110 hours).			For first 86 hours.		
	Hourly rate for—		Q_{10}	Hourly rate for—		Q_{10}	Hourly rate for—		Q_{10}
	Higher temperature.	Lower temperature.		Higher temperature.	Lower temperature.		Higher temperature.	Lower temperature.	
°C.	0.01 mm.	0.01 mm.		0.01 mm.	0.01 mm.		0.01 mm.	0.01 mm.	
13–23	126	30	4.2	49	7	7.0	28	....	....
14–24	133	44	3.0	52	11	4.3	30	....	....
15–25	140	58	2.4	55	16	3.4	32	....	....
16–26	146	70	2.1	60	20	3.0	37	....	....
17–27	151	82	1.8	63	25	2.5	39	10	3.9
18–28	155	91	1.7	66	29	2.3	40	12	3.3
19–29	157	99	1.6	67	33	2.0	42	16	2.6
20–30	156	106	1.5	66	37	1.8	43	19	2.3
21–31	153	113	1.4	66	42	1.6	42	23	1.8
22–32	146	120	1.2	63	45	1.4	40	25	1.6
23–33	139	126	1.1	61	49	1.2	37	28	1.3
24–34	131	133	1.0	57	52	1.1	34	31	1.1
25–35	124	140	0.9	53	55	1.0	31	32	1.0

It has been customary to discuss temperature coefficients as though they were constant for each process, at least constant for a considerable range of temperature ranges, and the "van't Hoff principle" in this connection has been stated to the effect that chemical processes have a value of Q_{10}, about 2.0 or 2.5. As Fawcett has emphasized, however, the value of Q_{10} for any process whatever varies in magnitude from infinity to zero, and the process is best characterized (as to its temperature relations) by showing just how this variation occurs. For the growth data here considered this is readily shown by graphs such as those presented in fig. 2, in which the several temperature ranges are abscissas and the coefficient values are ordinates. Inspection of these graphs shows that the temperature coefficients for shoot growth in these seedlings follow the general law for such coefficients; for low-temperature intervals the value

is of course very high and for high intervals it is very low, but the graphs extend only from interval 13°–23° to interval 25°–35° for the entire period and the last twenty-four hours, and from interval 17°–27° to interval 25°–35° for the first eighty-six hours. Like all other processes (whether physical or chemical), this process of shoot growth shows one interval in each graph for which the value of Q_{10} is about 2.5; but this interval is not the same in the three cases. For the last 24-hour period it is between 15° and 25°, for the 110-hour period it is between 17° and 27°, and for the 86-hour period it is between 19° and 29°.

These differences illustrate the fact, already emphasized by other writers that the Q_{10} value, for any 10° temperature interval with a finite value of the coefficient, varies not only with the particular 10° temperature range for which it is calculated but also with the nature of the process dealt with. For the three cases at hand the form of the coefficient graph appears to have been determined (as Lehenbauer also found, for maize seedlings) by the length of the experiment period. This probably means that the form was determined by internal conditions, by the particular type of growth that was involved for each period.

Any kind of plant growth (such as shoot elongation, which was measured in these studies) is of course the resultant of many component physiological processes, and the temperature relation of the resultant growth must be considered as the resultant of the temperature relations of all the component processes taken together. It is not yet possible to attempt any promising study of the many components, but we readily secure evidence that there is a definite relation, as shown by the graphs of temperature coefficients, between temperature and the resultant complex, measured as growth. Also, for any instant in the development of plants such as those here considered the growth rate may be different from that for any other instant; the rate begins very low, is more or less gradually accelerated for a time and is finally retarded until it ceases altogether. For this grand march of the growth rate there may, of course, be one or more longer or shorter periods during which the rate does not alter perceptibly, and it may increase and decrease several times before coming to a stop. On the grand march of the growth rate, which is considered as determined by internal conditions for any given set of external conditions, is always superimposed, in nature, the influence of the fluctuating surroundings; but

these cultures are considered as having all been treated alike in all respects excepting for the differences in maintained temperature. The original internal differences from seed to seed and the chemical differences from solution to solution are considered as having been overcome, for our purposes, by the process of averaging that gave the growth rates before us. Therefore, the differences between the three curves of fig. 2 represent

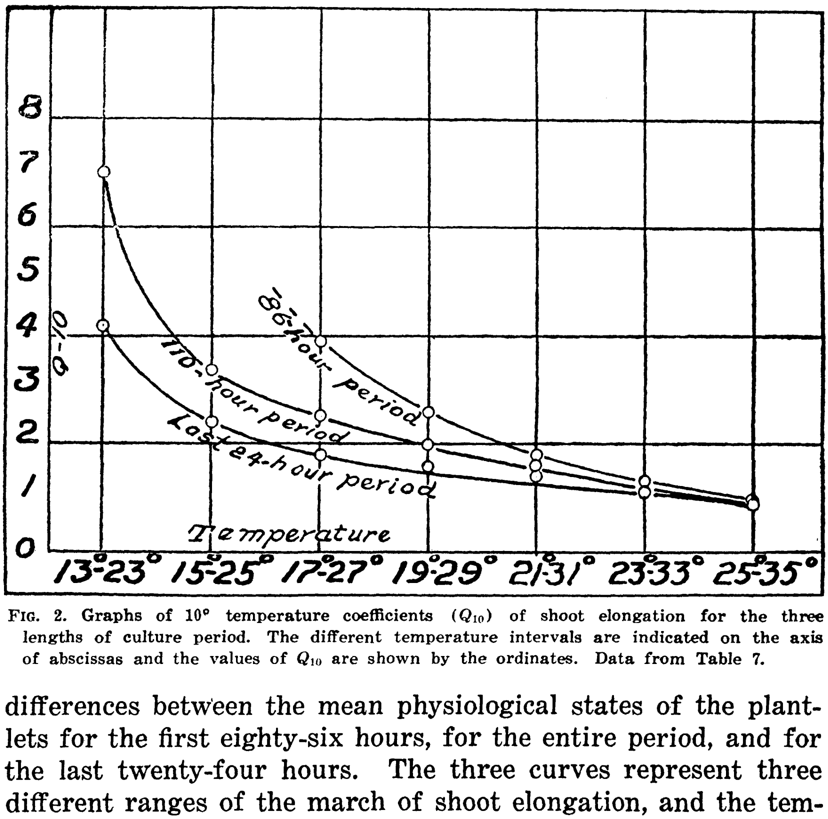

FIG. 2. Graphs of 10° temperature coefficients (Q_{10}) of shoot elongation for the three lengths of culture period. The different temperature intervals are indicated on the axis of abscissas and the values of Q_{10} are shown by the ordinates. Data from Table 7.

differences between the mean physiological states of the plantlets for the first eighty-six hours, for the entire period, and for the last twenty-four hours. The three curves represent three different ranges of the march of shoot elongation, and the temperature coefficient of the mean growth rate for one range alters from interval to interval in a way different from that followed by the coefficient for the mean growth rate for another range. The three periods differ in this respect somewhat as though three different kinds of organisms were represented.

It is interesting to note that the coefficient curve for the entire temperature range dealt with, rises most rapidly in the case of the earlier part of the period and least rapidly in the case of the later part of the period, while it has an intermediate

position in the case of the entire period of about one hundred ten hours. If the 86-hour period had been sufficiently longer, or if the 24-hour period had been sufficiently shorter, the three curves might have been equidistant from one another in the abscissa region represented by the available data. All three curves approach having a common ordinate of unity for the temperature interval from 24.5° to 34.5°, which is additional evidence that the optimum temperatures for all three lengths of period lay in the vicinity of 29.5°. If very narrow temperature intervals were used, instead of intervals of 10°, it should be possible in this way to fix the optimum temperature corresponding to each curve with any desired degree of precision, for the optimum temperature is clearly the middle point of a very narrow temperature interval for which the coefficient value is unity. This might be accomplished mathematically.

SUMMARY

The study reported in this paper was undertaken in connection with a plan for coöperative research on the salt requirements of plants, under the auspices of a committee of the Division of Biology and Agriculture of the National Research Council. The early growth of Marquis wheat was studied, for seven maintained temperatures (13, 17, 21, 25, 28, 31, and 35° C.) and for the first five days after the soaking of the seed began. One hundred twenty-six 3-salt solutions were used, containing the main essential chemical elements in different proportions but all having the same total osmotic value (equivalent to 0.1 atmosphere of osmotic pressure). Distilled water was also used. Twenty-five selected seeds were used in each test, and all tests were repeated once. The seeds rested on paraffined cotton-thread netting stretched at the surface of the liquid and all were in contact with the liquid, but none was submerged. The constant-temperature chambers showed less than a degree of fluctuation. Light was excluded.

The results indicate that all of the solutions tested were about equally satisfactory for the germination and very early growth of this seed; the range in salt proportions was large, but no solution showed clear evidence, on the whole, of giving better growth than any other. More-concentrated solutions or a longer experiment period might be expected to show differences. All of the solutions are to be regarded as about alike in their suitability for producing seedlings 4 or 5 centimeters high. On the other hand, the solutions all agreed in giving much better growth

than did distilled water, for all temperatures tested excepting the lowest, for which all growth rates were very slow.

Since all solutions were to be considered as nearly alike, the results of all solution cultures for each temperature were averaged, to secure an average hourly rate of shoot elongation for the entire period (about one hundred ten hours), for the first eighty-six hours, and for the last twenty-four hours. For all three periods the optimum temperature, as shown by these averages, lay between 29° and 30°, and any temperature between about 28° and 31° may be expected to give about the maximum rate of development for such seeds and solutions as those used. To produce seedlings with shoots about 4 centimeters high, with optimum temperature, a period of about ninety-five hours was required after the seeds were placed in contact with the solution, or a period of about twenty-five hours after the shoots emerged from the seed coats. From the graphs of this paper temperatures may be selected to give any desired rate of shoot elongation.

The average hourly rates of shoot elongation for the three periods and for each of the temperatures employed are as follows, expressed in terms of hundredths of a millimeter:

	Temperature, °C.						
	13	17	21	25	28	31	35
For first part of period, about 86 hours (solutions)	....	9.5	23	32	40	42	31
For last 24 hours of period (solutions)	30	82	112	137	157	153	124
For entire period of about 110 hours (solutions)	7	24	42	55	66	66	53
Distilled water	7	16	22	31	36	33	30

No relation was shown either between solution composition and the viability of the seeds or between this and temperature.

The growth-temperature graphs are nearly symmetrical about the vertical line for the temperature 29°.

The temperature coefficients of shoot elongation for temperature intervals of 10° and for the three periods are shown as graphs. All three coefficient values are close to unity for the 10° interval centering at 29.5° (about the optimum temperature). For lower temperatures the curvatures of the three coefficient graphs are very different. For the interval centering at 22° the coefficient values are as follows: First eighty-six

hours, 3.9; entire period, 2.5; last twenty-four hours, 1.8. These differences reflect alterations in the nature of the process measured, as time went on; shoot elongation was not measurable for the earlier hours and it became rapid for the later ones.

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ILLUSTRATIONS

TEXT FIGURES

PHOTOMICROGRAPHS OF PHILIPPINE STARCHES

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TEN PLATES

INTRODUCTION

Although the Philippine Islands have many varieties of starch-producing plants, both cultivated and wild, about 3,000,000 kilograms of starch, worth over 500,000 pesos, are imported annually, according to Bureau of Customs reports.[1] At present, there is not a commercial starch factory in the Islands.

Although some analyses of sweet potatoes [2] and other Philippine tubers [3] have been made, only a very few photomicrographs of Philippine starches are recorded in the literature.[4] The present investigation was undertaken for the purpose of preparing photomicrographs of starch grains from Philippine tubers. The results show that, in general, starches from different specimens of the same species are very similar in microscopic appearance, while starches from different species are usually quite unlike.

MATERIALS

Starches were prepared from one hundred two samples of tubers and one cycad trunk, comprising fourteen species in all, grown in different parts of the Islands and under varying conditions. The several samples were obtained as the fresh roots, mainly from the various Government experiment stations through the coöperation of Dr. Stanton Youngberg, director of the Bureau of Agriculture, and Mr. A. F. Fischer, director of the Bureau of Forestry, who courteously extended the resources of their organizations in the procurement of the material needed.

In nearly all cases, leaves and stalks accompanied the tubers and were identified botanically by Dr. L. M. Guerrero, of the

[1] Annual Report of the Insular Collector of Customs (1923–1926), Bureau of Customs, Manila.

[2] Labayen, S. D., Philip. Agriculturist and Forester 3 (1914) 79–80.

[3] Quisumbing, F. A., Philip. Agriculturist and Forester 3 (1914) 85–98 and 99–110.

[4] Bacon, R. F., Philip. Journn. Sci. § A 3 (1908) 93–98.

Bureau of Science, in order to avoid the inaccuracy and confusion of the multiplicity of common names in the various dialects of the Philippines. The tubers were also planted in a garden in the Bureau of Science grounds and botanical specimens grown for a further check. Description of the plants and tubers are given by Wester [5] and by Brown.[6]

EXPERIMENTAL PROCEDURE

PREPARATION OF THE STARCHES

Practically pure starches were prepared by peeling the tubers, grinding or grating the flesh, straining through muslin, settling, and washing. The grinding was done with either a large nutmeg grater or an ordinary kitchen food grinder, as expediency suggested. Washing was accomplished by settling and decanting three times in tap water and two or three times more in distilled water, or until the starch was as nearly white as possible; finally, the material was washed with alcohol followed by ether on a Buchner funnel connected to the vacuum line. The starches were then dried in vacuum desiccators over calcium chloride or sulphuric acid.

Most of the starches settled out quickly and were white, but some of the tubers were mucilaginous and their starches persistently brown; these conditions are specifically mentioned under the description of the individual species. In the case of the more-mucilaginous tubers, the starch would remain in suspension in the liquor for days. To overcome this difficulty a Sharples laboratory supercentrifuge was installed and operated from the compressed-air line. This apparatus proved a successful solution of the problem, although the ubi starches so prepared still retained a brown color. All the slimy liquors, such as those obtained from ubi, gabi, and biga, were run through this machine. In some cases it was apparently impossible to separate starches by any other means, and in others, the machine tended to expedite the settling process and save time.

Five of the starch samples, as mentioned in the individual descriptions, were prepared by Dr. H. I. Cole, who started this research just prior to leaving the Bureau of Science to assume the position of chief chemist of the Culion Leper Colony.

[5] Wester, P. J., Philip. Agr. Rev. 14 (1921) No. 3.
[6] Brown, W. H., Bull. P. I. Bur. Forestry 21 (1920).

METHODS OF ANALYSIS AND DIFFERENTIATION

Photomicrographs were taken of each starch in ordinary and in polarized light, with a magnification of 300 diameters. Data concerning the different conditions for the individual photographs are given in Table 1.

TABLE 1.—*Conditions under which photomicrographs were taken.*

Figure No.	Name.	Light.[a]	Illuminant.	Mount.	Filter.
1	Kamote	O	100-watt Mazda	Water	None.
2	do	P	do	do	Do.
7	Biga	O	Pointolite	do	Yellow and blue.
8	do	P	Arc	Canada balsam	None.
9	Gabi	O	Pointolite	Water	Blue.
10	do	P	Arc	Canada balsam	None.
11	Palauan	O	Pointolite	Water	Blue.
12	do	P	Arc	Glycerine	None.
13	Ubi	O	Pointolite	Water	Yellow and blue.
14	do	P	do	do	Blue.
17	Tugi	O	do	do	Yellow and blue.
18	do	P	Arc	Canada balsam	None.
21	Lima-lima	O	Pointolite	Water	Yellow and blue.
22	do	P	do	do	Blue.
23	do	O	do	do	Yellow and blue.
24	do	P	do	do	Blue.
30	Aroro	O	do	do	Yellow and blue.
31	do	P	do	do	Blue.
32	Yab-yaban	O	do	do	Yellow and blue.
33	do	P	do	do	Blue.
34	Nami	O	do	do	Yellow and blue.
35	do	P	do	do	Blue.
36	Kamoting-kahoy	O	do	do	Do.
37	do	P	do	do	Do.
40	*Dioscorea flabellifolia*	O	do	do	Yellow and blue.
41	do	P	do	do	Blue.
42	*Cycas* sp	O	do	do	Yellow and blue.
43	do	P	do	do	Blue.
44	Mayatbang	O	100-watt Mazda	do	None.
45	do	P	do	do	Do.

[a] O, ordinary light; P, polarized light.

Two ordinary microscopes with polarizing attachments were used interchangeably. The cameras used were a Carl Zeiss 5 by 7 vertical model, a large horizontal Zeiss with arc illumination, and for a few of the photographs a Leitz Makam (9 by 12 centimeters); the last is a small, light camera, which is supported by the draw tube of the microscope itself. The vertical form of camera was preferred when using water mounts as it minimized

the movement of the starch grains and mounting medium, and the Pointolite lamp was found the most convenient illuminant.

Glycerine was found to be an excellent mounting medium for photographs in polarized light since its viscosity tends to minimize the motion of the smaller, more-mobile grains and permits the use of horizontal apparatus through lessened flowing of the medium from under the cover glass. It is rather more convenient for quick preparation than Canada balsam. Fuchsin and iodine stains were tried but not used.

The size of the starch grains was measured by an ordinary ocular micrometer. The smallest and largest sizes observed are given, together with the estimated average or commonest size. Careful examination has shown that the starch grains produced by a particular plant are remarkably constant in size, shape, and general characters.[7]

When the hilum is not in the center of the grain, its location is indicated "by measuring the distance between it and the nearer, as well as the further margin of the grain and stating the ratio between these figures, which expresses the degree of eccentricity, as a fraction. Thus in potato starch, the greater distance is about five times the lesser, and the eccentricity is, therefore, about $\frac{1}{5}$."[8] The center of the cross in polarized light is taken as coincident with the hilum. Photomicrographs and histological characteristics are given here as means of identification rather than chemical and physical tests. Specific reactions, such as with ferric chloride, chloral hydrate, etc., as used by Reichert[9] and by Planchon and Juillet[10] were tried but not given much emphasis as they were considered of rather less value. Tests for cyanogenetic glucosides, using sodium picrate, were made[11] to ascertain which of the tubers were poisonous. Cassavas were the only positive ones.

A satisfactory method of determining the percentage of starch in tubers is given under the discussion of the starch from

[7] Greenish, H. G., The Microscopical Examination of Foods and Drugs (1923) 1.

[8] Greenish, op. cit. 4.

[9] Reichert, E. T., The Differentiation and Specificity of Starches in Relation to Genera, Species, etc. (1913).

[10] Planchon, L., et A. Juillet, Étude de Quelques Fecules Coloniales (1910).

[11] Allen's Commercial Organic Analysis 7 (1913) 470.

yab-yaban. No special effort was made to secure a quantitative yield of starch in the extraction from the tubers, since quantitative analyses of most of the tubers have been made by previous workers, whose results are quoted here. In a few cases records were made of the percentage of dry starch obtained from weighed amounts of the fresh, peeled tubers. This was only possible when the tubers were received soon after harvesting; many of them were shipped to Manila by interisland boat and were a week or two in transit, with consequent loss of moisture.

A complete, efficient extraction of the starch was not obtained or sought, but since all tubers were treated as nearly as possible in the same manner, the figures in Table 2 will give an idea of the relative ease or difficulty of extraction. They should not be taken as showing the yield that might be obtained in an efficient commercial starch factory, as they are too low.

The six moisture determinations in Table 3 are given simply as a guide to the amount of water that may be expected in such tubers.

TABLE 2.—*Yield of dry starch from the wet peeled tubers.*

Name.	Number of samples.	Yield.	
		Range.	Average.
		Per cent.	*Per cent.*
Kamote	6	7.5–15.5	12.4
Biga	1	16.4	16.4
Gabi	5	1.4–16.7	9.1
Wild ubi	1	8.1	8.1
Yab-yaban	1	16.8	16.8
Ubi	7	1.5– 7.1	4.8
Palauan	1	5.8	5.8
Cassava	1	11.7	11.7
Tugi	6	4.4–13.8	10.2

TABLE 3.—*Moisture content of tubers.*

Name.	Number of samples.	Moisture.	
		Range.	Average.
		Per cent.	*Per cent.*
Kamote	4	59.4–62.2	61.2
Ubi	1	76.5	76.5
Yab-yaban	1	68.0	68.0

THE TUBERS AND THE STARCH GRAINS

CONVOLVULACEÆ

IPOMOEA BATATAS (Linnæus) Poiret; Kamote (Tagalog); Sweet potato (English). Plate 1, figs. 1, 2, and 3.

These tubers are obtained from a perennial vine cultivated as an annual for its starchy roots. The boiled leaves are also edible. The average starch content is about 20 per cent but varies according to the variety, the soil, and the climate. This is the most important root crop in the Philippines, of which many native and imported varieties are grown. The yield is given as 10,000 kilograms per hectare.

The starch is easily extracted and settles out well in water, giving a white product. The kamote is one of the promising sources of commercial starch.

Disease, insect pests, and storage rots all affect kamotes in the Philippines, and these facts must be considered when planning large-scale cultivation such as would be required to support a starch industry. Detailed descriptions of these diseases and pests are given by Kingman and Doryland.[12]

The kamote starch grains are either round or dome-shaped, with the hilum distinct and the rings concentric. The size ranges from 4 μ for the smaller grains to 30 μ or more for the larger, with an average of 15 to 18 μ. There are approximately equal numbers of all the sizes. In polarized light the cross is distinct and centric to one-fourth eccentric. The starch was extracted from nineteen samples of kamote.

ARACEÆ

COLOCASIA ESCULENTUM Schott; Gabi (Tagalog); Taro (English). Plate 2, fig. 5; Plate 3, figs. 9 and 10.

The gabi is a perennial aroid cultivated as an annual for its starchy tubers, which are eaten like potatoes. The boiled leaves are also eaten. It is the third most important root crop in the Philippines, ranking next to the kamote and the ubi. The average starch content is about 18 per cent with considerable variation according to the variety.

Kingman and Doryland[13] state that the Philippine Bureau of Agriculture has not encouraged the growing of the gabi because of the productivity of other crops, such as the sweet po-

[12] Kingman and Doryland, Philip. Agr. Rev. 10 (1917) 346–7.

[13] Op. cit. 343.

tato, which can be raised more readily and give greater returns per hectare.

The gabi commonly contains sharp, needlelike crystals of calcium oxalate and must, therefore, be peeled and cooked carefully for eating. These crystals irritate the hands when the tubers are being peeled, ground, and macerated for starch extraction so that it was found advisable to wear rubber gloves when working with them for any length of time.

Gabis, as a rule, are mucilaginous or slimy, and the gummy substance renders the settling and wash waters so viscous that these tubers are generally unsatisfactory as a source of starch, since this condition, in conjunction with the small size of the grains of starch, prevents the latter from settling to the bottom.

One variety of gabi from Cebu (humnao) was found that was an exception to the general rule, as it was not irritating to the skin and was not sticky when worked. The humnao variety has grayish white flesh interspersed with short curly purple veins which resemble the silk threads in bank notes. The juice in water is red. It is easily worked, and the starch settles out well.

Gabi starch ranges from 0.2 μ to as much as 10 μ in size, with about 3 to 4 μ as the average. The grains are small polygons of about five sides; the hilum is sometimes visible on the larger sizes. The polarization cross is dim, but symmetrical or centric with arms at 90° to each other. Twelve samples of gabi starch were prepared.

ALOCASIA MACRORRHIZA (Linnæus) Schott; Biga (Tagalog). Plate 2, fig. 4; Plate 5, figs. 7 and 8.

This species is not cultivated, but the stems and the corms are utilized to some extent as food. Quisumbing,[14] who studied the corms of a two-year old plant, reported that the percentage of starch from fresh stems was 2.75, and from dry ones 18.80.

Four samples of biga starch were prepared. The starch grains are small, irregularly shaped polygons of four or five sides, ranging from 1 μ to 5 μ in diameter and averaging about 3 to 4 μ. The hilum and rings are not visible. The polarization cross is dim, but, as a rule, symmetrical.

CYRTOSPERMA MERKUSII Schott; Palauan (Tagalog); English name not known. Plate 2, fig. 6; Plate 3, figs. 11 and 12.

The large, starchy rootstocks of this aroid are used as food in time of scarcity. The plant is grown to a limited extent in

[14] Philip. Agriculturist and Forester 3 (1914) 85–98.

the Visayas and southern Luzon. The starch content is about 7.5 per cent.

The starch has medium-sized, rounded, and angular-rounded grains from 4 to 18 μ in size, with the average about 11 μ. The grains show pressure facets, resembling a cut stone in many cases. The hilum is visible on very few and is a Y or a straight line. The polarization cross is distinct and is slightly asymmetrical, but centric.

DIOSCOREACEÆ

DIOSCOREA ALATA Linnæus; Ubi (Tagalog); Yam (English). Plate 4.

The ubi is obtained from a widely distributed perennial herb which is cultivated as an annual. There are several distinct varieties in the Archipelago, varying in shape, size, color, and quality of the tubers, ranging from white to dark purple, globose to long and slender. It is the second most important root crop in the Philippines. The average starch content is about 21 per cent with some variation according to variety.

The flesh of ubis has a coarse texture and is very mucilaginous, so that the starch does not settle out at all well in the extraction water. It was found necessary to centrifuge all ubis to make the starch settle out of the slimy liquor.

Twenty-four samples of ubi starch were prepared. The grains are transparent, and may be oval or rounded-triangular, with approximately equal numbers of the different sizes. The smallest ones vary from 8 to 20 μ, and the largest from 33 to 60 μ in length; the average size is about 26 μ wide and 30 μ long. No ring or hilum is visible. The brilliant polarization cross is about one-seventh eccentric with its center near the narrow end of the grain.

DIOSCOREA ESCULENTA Burkill; Tugi (Tagalog); Yam (English). Plate 5.

The tugi is a perennial herb with underground tubers and is cultivated as an annual. There are several well-recognized varieties distinguished by the prevalence and size of subterranean spines, and by the size, form, and quality of the tubers. It is widely distributed but not extensively cultivated. In food quality, the best varieties outrank all other root crops in the Philippines. The average starch content is about 23 per cent.

Eleven samples of starch were prepared from tugis. The tugis worked were slightly mucilaginous, but the starch extracted quite easily and settled out well and in a clean, white condition.

The starch grains are mostly small pentagons, from less than 1 μ to more than 8 μ in size; the average is 4 μ. The smaller

sizes are more numerous, and aggregates of the grains are common. The polarization cross is slightly eccentric. The arms of the cross may be at right angles or not, and one arm may be straight while the other appears curved.

DIOSCOREA PENTAPHYLLA Linnæus; Lima-lima (Tagalog); Yam (English). Plate 6.

Lima-lima is a tuber that may be eaten like potatoes and is obtained from an herbaceous vine. There are two very distinct forms. (See figs. 25 and 26; the leaf of the first has five leaflets, while that of the latter usually has three leaflets.) The average starch content in about 18 per cent.

Three samples of lima-lima starch were prepared. The tubers were only slightly mucilaginous, and the starch settled out well in water. The 3-leaflet specimen contained some black material in the white starch and, as it could not be separated, the final product was gray.

The starch has huge elongated oval or deformed oval grains from 20 μ to as much as 100 μ in length, with 30 to 40 μ as the average size. The rings are distinct, while the hilum is always invisible. A nipplelike form at one end, like that of ginger starch, is found on the grains from the 5-leaflet variety. A conchoidal shape characterizes the 3-leaflet sample. The polarization cross is distinct, striking, and about one-fifteenth eccentric. The intersection is very near the pointed or narrow end of the grain.

DIOSCOREA HISPIDA Dennstedt; Nami (Tagalog); Yam (English). Plate 7, fig. 29; Plate 8, figs. 34 and 35.

The nami is a starchy, poisonous tuber which is rendered edible by immersing the sliced tuber in running water for thirty-six to forty-eight hours. It averages about 18 per cent in starch content with slight variations. There are at least two distinct varieties in the Philippines, one with "hairy" and one with smooth tubers.

One sample of nami starch was prepared. This tuber was very easy to work and gave a milky liquor with the wash water, from which the starch settled very quickly in a clean white state.

The grains are small pentagons with more or less rounded corners ranging from 1 to 4 μ in size and averaging 3.5 μ. Aggregates are common. No hila or rings were observed. The dim polarization cross is centric or very slightly eccentric.

DIOSCOREA LUZONENSIS Schauer; Mayatbang, Kirini, or Pakit (Tagalog); Yam (English). Plate 10, figs. 44 and 45.

This tuber is long and slender; it is not cultivated because of the difficulty in digging it from the soil.

One sample of mayatbang starch was prepared by Dr. H. I. Cole. The grains under the microscope resemble large, round or oval, water-worn rocks and have few hila and no rings visible. They range from 12 to 48 μ in width and from 30 to 67 μ in length; the average is about 26 μ and 35 μ, respectively. The sizes are present in approximately equal numbers. The polarization cross is striking and about one-third eccentric.

DIOSCOREA FLABELLIFOLIA Prain and Burkill; Local names unknown; Yam (English). Plate 10, figs. 40 and 41.

The starch from one sample of this wild tuber was prepared by Dr. H. I. Cole. The grains are smooth triangles with rounded corners and range in size from 12 μ wide and 20 μ long to 27 μ wide and 52 μ long, with an average of 23 μ in width and 30 μ in length. There are fewer of the smaller grains. The rings and the hila are not visible. The polarization cross is about one-seventh eccentric, with the center close to the narrow end of the grain, and very distinct as is usual with the larger *Dioscorea* starch grains.

MARANTACEÆ

MARANTA ARUNDINACEA Linnæus; Aroro (Tagalog); Arrowroot (English). Plate 7, fig. 27; Plate 8, figs. 30 and 31.

This tuber is obtained from a perennial herb from which the arrowroot starch of commerce is made. It is of fairly general distribution but rarely cultivated in the Philippines. The roots contain about 19 per cent of starch.

Two samples of arrowroot starch were prepared. It extracts well and the product is clean and white. The starch grains, which are round or nearly so, are from 8 to 33 μ in diameter; the average is 22 to 25 μ. There is an approximately equal occurrence of all the sizes. The hilum is distinct as a short straight line. Rings are not always evident. The polarization cross is centric to one-third eccentric and very distinct, with unusually broad lines.

EUPHORBIACEÆ

MANIHOT UTILISSIMA Pohl; Kamoting-kahoy (Tagalog); Cassava (English). Plate 9.

This perennial is of universal distribution, but cultivated rarely except in the Sulu Archipelago where it is a staple food. Under ordinary conditions in the Philippines, a conservative estimate of the yield per hectare of merchantable roots from plants

one year old or more is about 25 tons. Average roots contain 25 to 30 per cent starch, about 80 per cent of which is secured in the process of modern manufacture.

The enemies of cassava are few in the Philippines. Old roots left in the ground are often chambered or consumed by insects, but young fresh roots are never attacked. No disease of cassava is known in the Philippines. The principal difficulty in cultivating it is to prevent the ravages of wild hogs.[15]

Twenty-one samples of cassava starch were prepared. The starch extracts easily, settles out well, and gives a clean white product. Cassavas contain cyanogenetic glucosides and are poisonous, but after the tubers have been roasted or boiled properly they are edible.

The starch grains are round and dome-shaped and resemble kamote (sweet potato) starch but are smaller. The hilum is distinct, with the form of a Y or a very flat V like the wings of a flying bird. The rings are faint. The grains range from 3 to 20 μ in size; the average is about 11 μ. Approximately equal numbers of the sizes are found. The polarization cross is distinct, symmetrical, and centric, with the arms at right angles to each other.

TACCACEÆ

TACA PINNATIFIDA Forester; Yab-yaban (Tagalog); Polynesian or East Indian arrowroot (English). Plate 7, fig. 28; Plate 8, figs. 32 and 33.

This plant has somewhat rounded or oval tubers up to 8 centimeters in diameter, perhaps larger in rich soil. Bacon [16] found that the tubers yielded 22.3 per cent of very pure starch, which was easily extracted. It is known in commerce as Polynesian or East Indian arrowroot starch. The plant, however, is apparently little utilized in the Philippines and is never cultivated. The starch must be washed several times to eliminate the bitter principle found in the fresh tubers.

One sample of yab-yaban starch was prepared from a sample submitted by an official of the Bureau of Commerce and Industry, who was interested in the commercial possibilities of this starch in the Philippines. An analysis was made with the following results:

Moisture, per cent	68
Starch, on wet basis, per cent	24.03
Starch, on dry basis, per cent	75.1
Cyanogenetic glucosides	None
Alkaloids	None

[15] Kingman and Doryland, Philip. Agr. Rev. 10 (1917) 338–340.
[16] Philip. Journ. Sci. § A 3 (1908) 96.

The starch was determined by the acid hydrolysis method and Fehling's solution [17] as follows:

The tuber was peeled and ground in an ordinary kitchen food chopper, and approximately 10 grams of the pulp were weighed into a beaker to which 50 cubic centimeters of water were added. The mixture was allowed to stand with occasional stirring for an hour, then filtered, and the pulp washed with ether and alcohol. When the filtrate was cloudy it was centrifuged, and the solid matter so obtained, together with the filter paper and its contents, was placed in a reflux apparatus with 200 cubic centimeters of water and 20 cubic centimeters of dilute hydrochloric acid (specific gravity, 1.125), after which it was heated (reflux) for two and one-half hours. The contents of the flask were then cooled, neutralized with sodium hydroxide, and the volume diluted to 500 cubic centimeters. The solution was filtered, and the dextrose in a 25 cubic centimeter portion was determined by Fehling's solutions. The precipitated cuprous oxide was dissolved and the copper checked electrolytically. Leach gives tables converting the weight of copper obtained to the weight of dextrose present.[18] Taking 0.9 as the factor for converting dextrose to starch, then—

$$\frac{\text{Weight of dextrose} \times 0.9 \times 500 \times 100}{25} = \text{Per cent of starch.}$$

The grains of yab-yaban starch are round or horseshoe-shaped with the hilum distinct as a short straight or wavy line. They resemble the grains of kamote starch but are slightly larger. The rings are visible on larger grains. The size ranges from 8 to 40 μ, with 20 μ as the average. A lesser proportion of the smaller sizes is observed. The brilliant polarization cross is centric to one-half eccentric; one arm is often curved.

CYCADACEÆ

CYCAS sp. A cycad indigenous to Culion Island. Plate 10, figs. 42 and 43.

This cycad is an undescribed species. It has a pithy, starchy core which fills most of the trunk, while the outside wood is simply a shell. This species does not occur in quantity sufficient to be of commercial importance.

[17] Leach, A. E., Food Inspection and Analysis (1907); and United States Department of Agriculture, Bureau of Chemistry Bulletin No. 107, Revised, Official and Provisional Methods of Analysis, Association of Agricultural Chemists (1925) 119.

[18] Op. cit. 493–495, under Allihn's method for the determination of dextrose.

Starch was prepared from one sample of this cycad. The hard, thin outside was peeled off and the pithy core ground and treated as in preparing the starches from tubers. The small pieces of ground core are rather hard, so that fine grinding is essential to a good recovery of starch.

The starch grains are round, with distinct hilum showing as a cross, a Y, or a straight line. The size of the grains ranges from 3 to 19 μ, with an average size of 11 to 14 μ. The smaller ones are more numerous. The polarization cross is distinct, symmetrical, and centric, with arms at 90° to each other.

DISCUSSION OF RESULTS

Kamote, yab-yaban, aroro, nami, and kamoting-kahoy starches were all found easy to extract in pure, white form by methods such as would be used commercially. These plants have potential economic value as sources of commercial starch in the Philippine Islands.

Starches from tugi, lima-lima, and the trunk of a new cycad were prepared with only slight difficulty.

As a rule, the larger the grains of a starch, the more easily it is extracted and washed. The ubi is an exception as it is so mucilaginous that the starch grains, although relatively large, settle very slowly out of the viscous mother liquor. Gabi and biga are also difficult to work as the starch grains are small and the tubers are mucilaginous.

Mayatbang and lima-lima starches have relatively huge grains, averaging some 40 to 50 μ in length. The latter is distinguished by distinct rings and a nipplelike protuberance at one end of the grain or by a curved cornucopia shape. In polarized light the cross has a much greater eccentricity than that of mayatbang.

Dioscorea flabellifolia, aroro, yab-yaban, ubi, and kamote starches have medium-sized grains of the order of 20 to 30 μ. Aroro and yab-yaban are round and similar, but the latter is distinguished by the presence of a few oval grains with flattened ends like a horseshoe, together with a slightly smaller average size of grains. *Dioscorea flabellifolia* starch resembles closely that of ubi, particularly since the latter varies somewhat in different plants. Rings are evident on the former and not on the latter. The ubi polarization cross shows slightly less eccentricity. Kamote starch is readily distinguished from any of the above starches by its combination of round and dome-shaped grains, distinct hilum, and only slightly eccentric polarization cross.

TABLE 4.—*Morphological characteristics of the starch grains.*

Names.	Length.		Appearance.	Rings.	Hilum.	Sizes.	Polarization cross.
	Extremes.	Average.					
	μ	μ					
Kamote; sweet potato; *Ipomea batatas.*	4–30	15–18	Round or dome-shaped; fissures common; convex.	Faint	Distinct line, V or Y	Equal numbers	Brilliant; centric to 1/4 eccentric.
Biga; *Alocasia macrorrhiza.*	1–5	3–4	Four- or 5-sided polygons; smooth.	None	None	do	Dim; symmetrical.
Gabi; taro; *Colocasia esculentum.*	0.2–10	3–4	Four- or 5-sided polygons; smooth; pressure facets.	do	Visible on large grains	do	Dim; centric; symmetric.
Palauan; *Cyrtosperma merkusii.*	4–18	11	Round or angular rounded; pressure facets.	do	Few	do	Distinct; centric; slightly asymmetric.
Ubi; yam; *Dioscorea alata.*	8–60	30	Oval or rounded triangular; smooth; transparent.	do	None	do	Brilliant; eccentricity 1/7.
Tugi; yam; *Dioscorea esculenta.*	1–8	4	Pentagons; smooth; pressure facets.	do	do	Less large grains	Dim; eccentricity slight; one arm often curved.
Lima-lima (3-leaved); yam; *Dioscorea pentaphylla.*	20–100	30–40	Conchoidal; convex	Distinct	do	Less small grains	Brilliant; eccentricity 1/15.
Lima-lima (5-leaved); yam; *Dioscorea pentaphylla.*	20–100	30–40	Oval with nipple at end; flat; smooth; translucent.	do	do	do	Do.
Aroro; arrowroot; *Maranta arundinacea.*	8–33	20–25	Oval or round; convex.	Rarely visible	Distinct as short line	Equal numbers	Brilliant; broad lines; centric to 1/3 eccentric.

Yab-yaban; East Indian arrowroot; *Tacca pinnatifida.*	8–40	20	Round or horseshoe-shape; convex.	Visible on larger grains.	do	Less small grains	Brilliant; centric to 1/2 eccentric; one arm often curved.
Nami; yam; *Dioscorea hispida.*	1–4	3.5	Pentagons with rounded corners; pressure facets.	None	None	Equal numbers	Dim; centric.
Kamoting-kahoy; cassava; *Manihot utilissima.*	3–20	11	Round and dome-shaped; convex; fissures; pressure facets.	Faint	Distinct as Y or flat V	do	Distinct; centric.
Dioscorea flabellifolia	20–52	30	Rounded triangles; flat; smooth.	None	None	Less small grains	Brilliant; eccentricity 1/7.
Cycas sp., from Culion	3–19	11–14	Round; convex; smooth.	do	Distinct stellate Y or short line	More small grains.	Distinct; centric; symmetrical.
Mayatbang; yam; *Dioscorea luzonensis.*	30–67	35	Round or oval; rough; convex.	do	Few	Equal numbers	Brilliant; eccentricity 1/3.

Among the smaller medium-sized starch grains, of the order of 10 to 12 μ, are those from kamoting-kahoy, the Culion cycad, and palauan. Kamoting-kahoy starch resembles the starch from kamote and may easily be mistaken for it, but the grains are smaller and show a symmetrical, centrally located cross in polarized light. The starch of the Culion cycad resembles that of kamoting-kahoy but has more uniformly rounded grains and a greater proportion of the smaller sizes. Palauan starch is distinguished by the ubiquitous pressure facets of the grains. It bears a superficial resemblance to corn starch but exhibits a more uniform and regular shape.

Nami, tugi, biga, and gabi starch grains are extremely small polygons of four or five sides, about 3 or 4 μ in diameter, and would be almost impossible to differentiate in a mixture by their appearance.

SUMMARY

Fourteen varieties of starches were prepared from one hundred two Philippine plant samples. Descriptions and photomicrographs are given as well as photographs and data of the tubers and plants from which the starches were obtained.

In general the several starches show marked physical differences which are recognizable in the photomicrographs.

The histological characteristics of various samples of starch prepared from the same plant species are remarkably constant and are practically independent of locality and growing conditions.

ILLUSTRATIONS

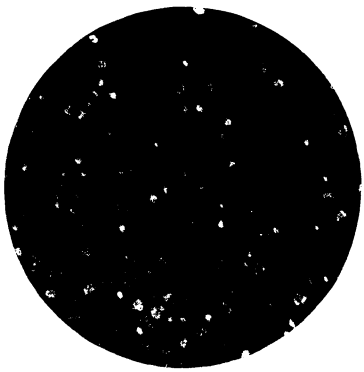
FIG. 33. Yab-yaban starch in polarized light.
34. Nami starch.
35. Nami starch in polarized light.

PLATE 9

FIG. 36. Kamoting-kahoy (cassava) starch.
37. Kamoting-kahoy starch in polarized light.
38. Kamoting-kahoy roots.
39. Kamoting-kahoy roots.

PLATE 10

FIG. 40. *Dioscorea flabellifolia* (yam) starch.
41. *Dioscorea flabellifolia* starch in polarized light.
42. *Cycas* sp. starch.
43. *Cycas* sp. starch in polarized light.
44. Mayatbang (yam) starch.
45. Mayatbang starch in polarized light.



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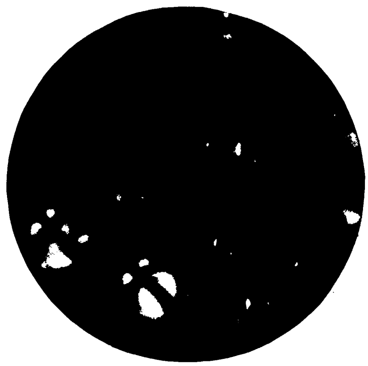

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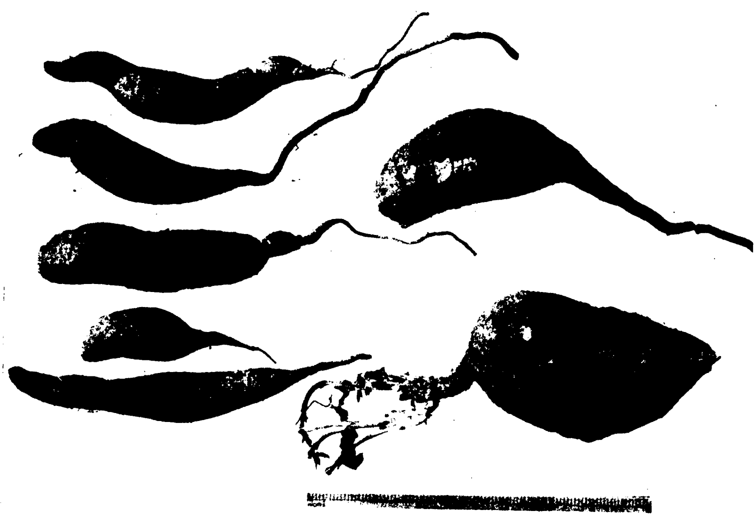

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PLATE 1.

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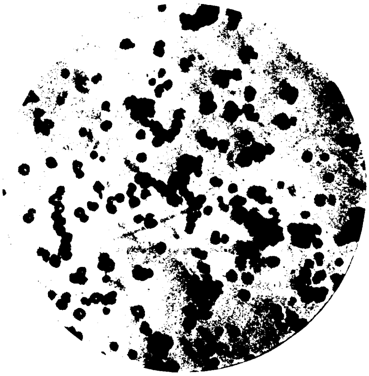
PLATE 2.



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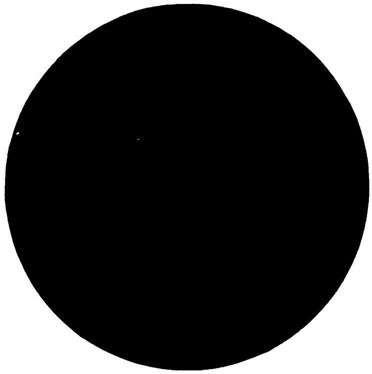

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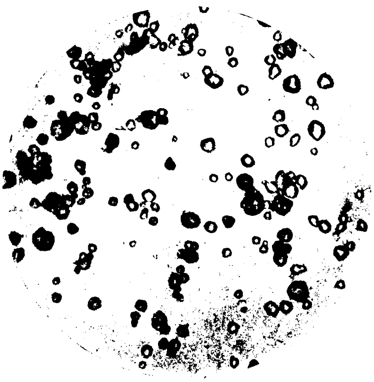

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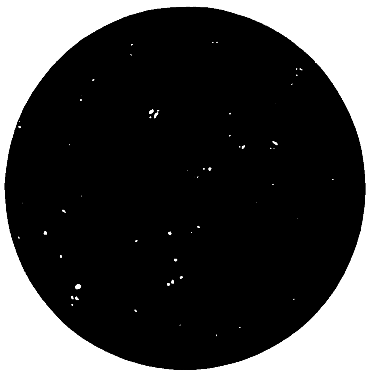

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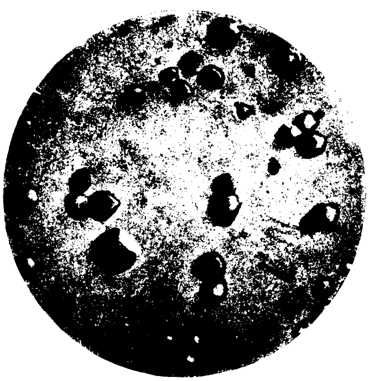

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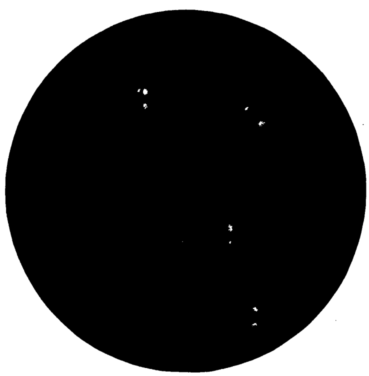

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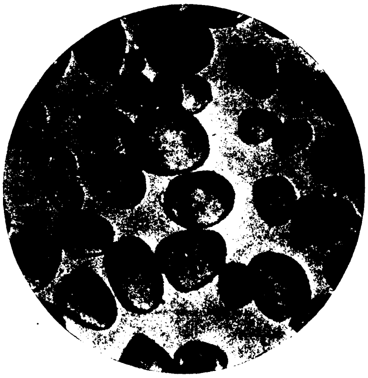

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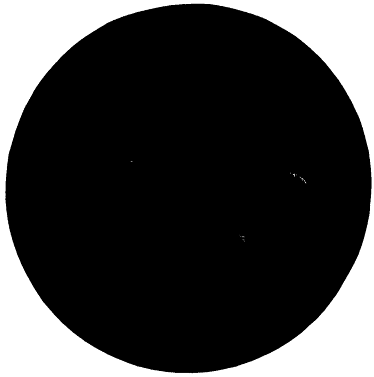

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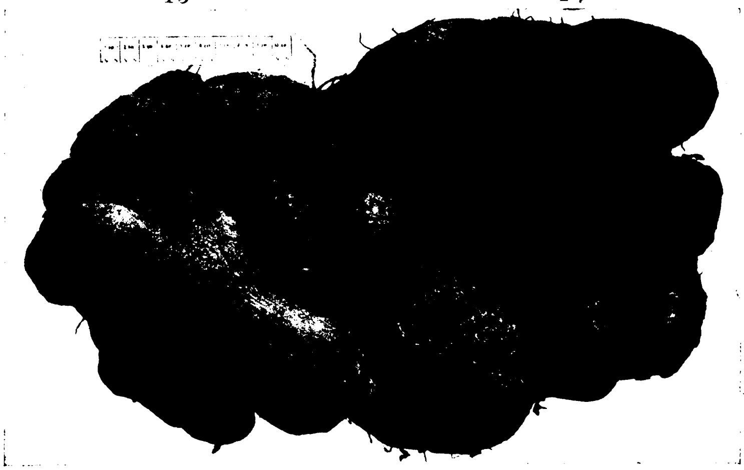

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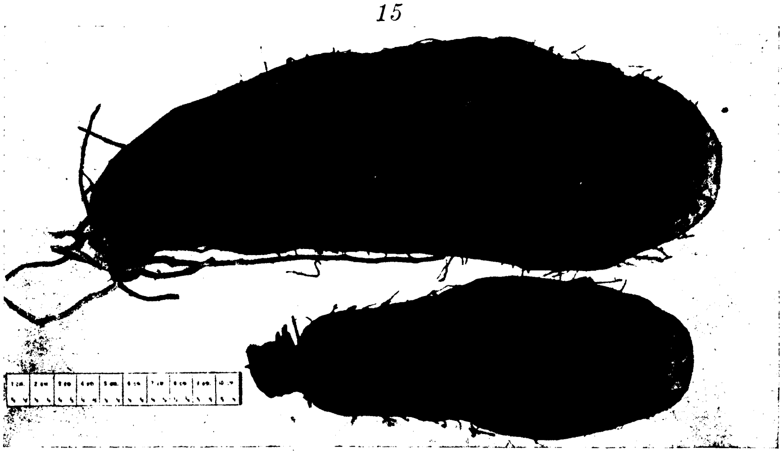

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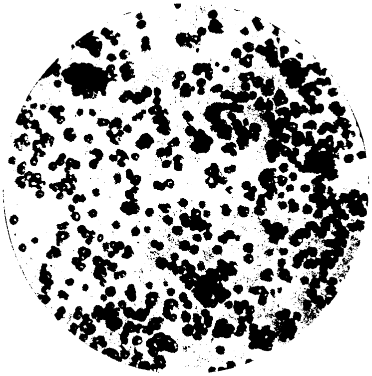

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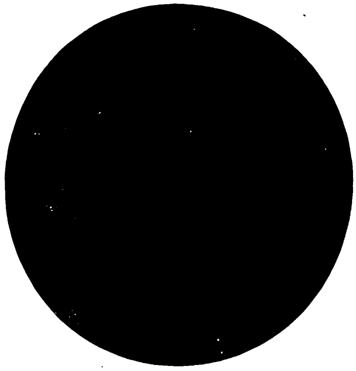

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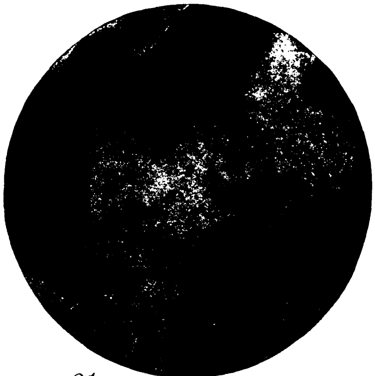

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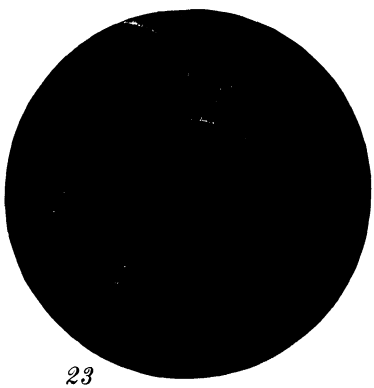

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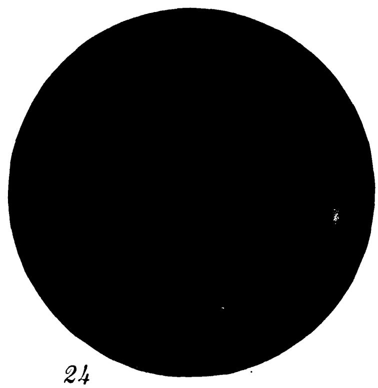

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PLATE 6.

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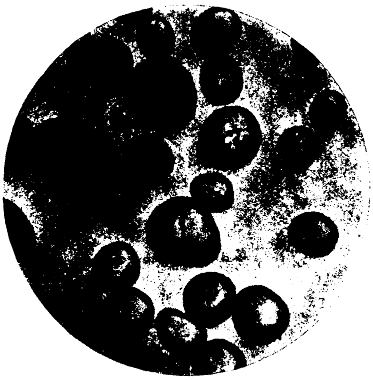
PLATE 7.



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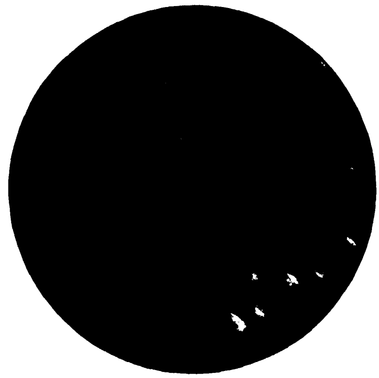

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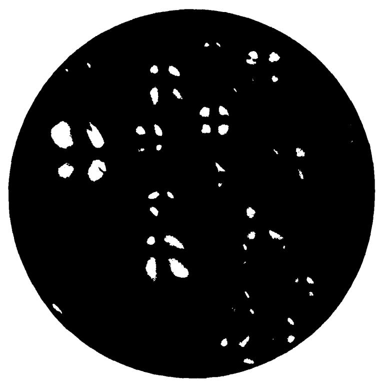

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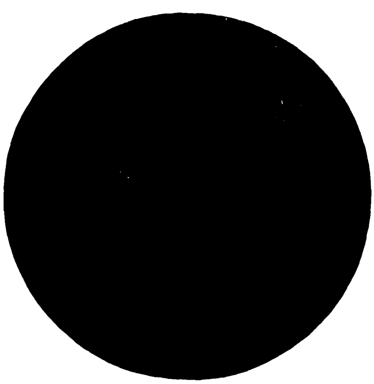

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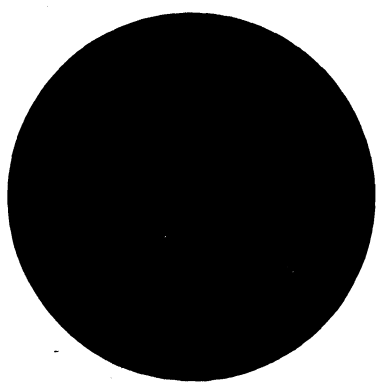

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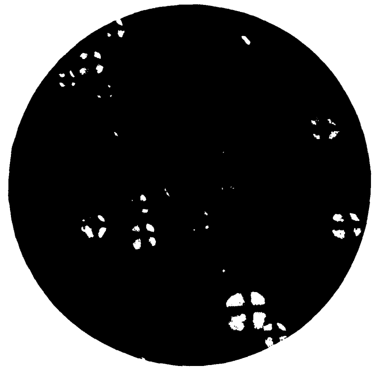

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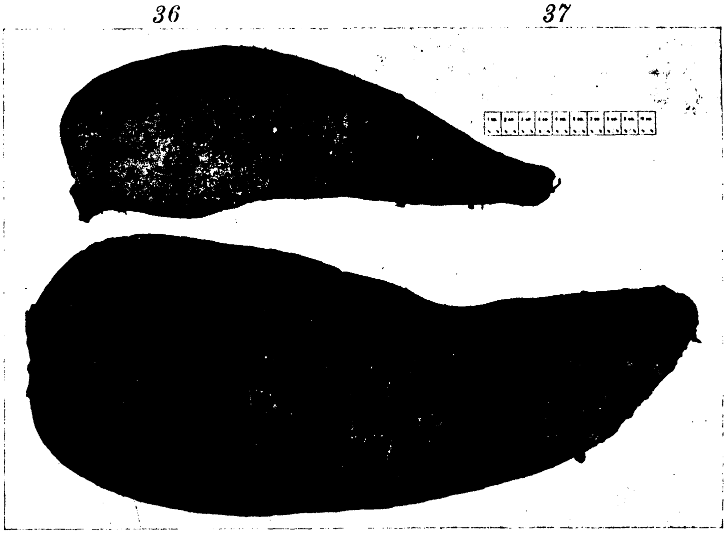

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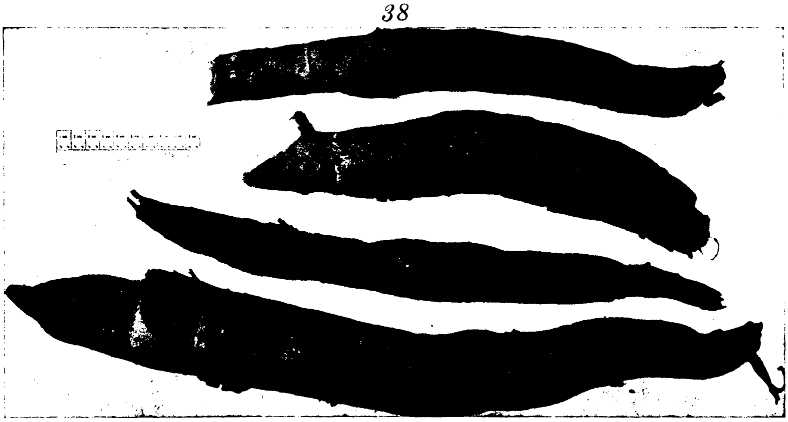

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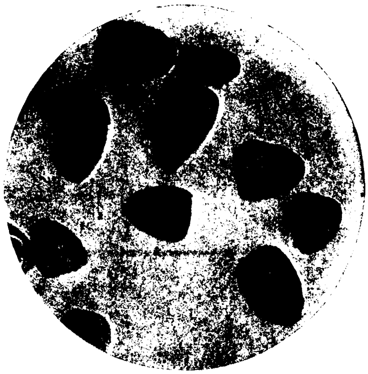

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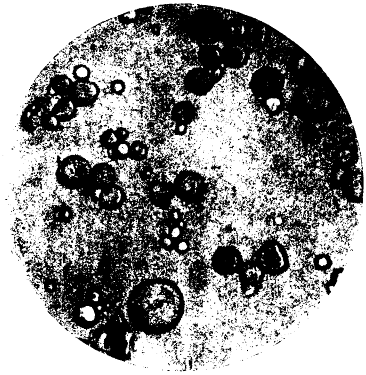

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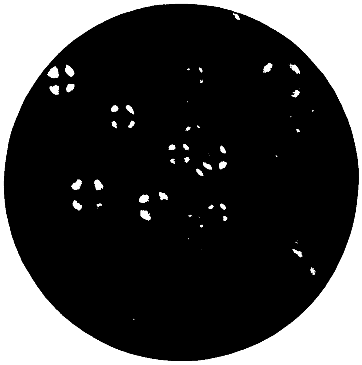

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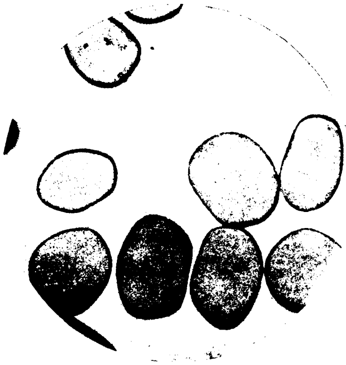

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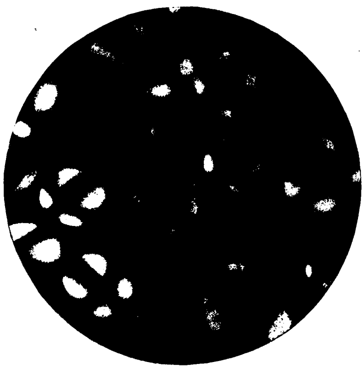

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 38 MARCH, 1929 NO. 3

AN ALKALOIDAL CONSTITUENT OF ARTABOTRYS SUAVEOLENS BLUME

By JOAQUIN M. MARAÑON

Of the Department of Botany, University of the Philippines and of the Bureau of Science, Manila

TWO PLATES

INTRODUCTION

With reference to their chemical constituents the members of the family Anonaceæ, to which the plant constituting the material for this investigation belongs, are generally conspicuous because of their aromatic principles. Many of these plants are reported to have certain medicinal and economic uses, as exemplified by some species of *Uvaria, Canangium, Popowia, Anona,* and *Papualthia.* Of the genus *Artabotrys,* Baillon [1] states that the aromatic infusion prepared from the leaves of *Artabotrys suaveolens* Blume is used in India for the treatment of cholera, while the volatile oil obtained from some of its species, especially *A. intermedia* Hasskarl, is considered as a perfume under the name "minjakkenangan" by the people of Java. Moreover, this genus is possibly represented by some plants possessing other pharmacologic properties if we take into account that the anonaceous plants as a whole are regarded as stimulant, tonic, stomachic, and febrifuge. Little, however, is known with respect to the occurrence of the alkaloid in *Artabotrys.* The

[1] Baillon, H., Histoire des Plantes 1: 273.

meager reports pertinent to this point are given by Greshoff [2] and De Rochebrune.[3] The former points out that the bark of the branches of *Artabotrys suaveolens* from the Dutch Indies contains about 0.10 per cent of an alkaloid accompanied by a blue efflorescent substance. This alkaloid has a slightly bitter taste, is precipitated by all alkaloidal reagents, and produces spasmodic contraction of the muscles when injected into a frog. The latter author indicates the presence of a crystalline substance in *Artabotrys madagascariensis* Miquel, which is called anonaceine since it is also present in other anonaceous plants analyzed. This substance is very soluble in water but insoluble in many organic solvents. It gives an orange precipitate with picric acid test solution, a deep brown color with the solution of potassium ferricyanide, and is found to be physiologically active. Its chemical nature was not given, but I believe that it is an alkaloidal salt, as judged by its behaviour toward different solvents and its reaction with picric acid.

Among the several species of *Artabotrys* in the Philippines, *A. odoratissimus* R. Brown [4] and *A suaveolens* Blume, according to Tavera,[5] contain active principles, which administered in therapeutic doses act as stimulants but when given in sufficiently large doses produce hæmorrhage, nervous phenomena, and abortion. A sample of the stems and roots of *Artabotrys suaveolens* was received by the section of poisonous and medicinal plants of the Bureau of Science for chemical analysis to determine the possible presence of physiologically active substances. It was found to be positive for the presence of an alkaloid, and since any local plant containing alkaloids is of considerable interest in the future formulation of the Philippine Pharmacopœia, this investigation was undertaken. The plant is known locally under various names; such as, *bahaibalagan* (C. Bis.), *kintubo* (Sub.), and *susong damulag* (Tag.). It is of wide distribution in the Philippines, and its pharmacognostic characteristics are described by Dr. José K. Santos in this issue of the Philippine Journal of Science.

[2] Greshoff, M., Mededeelingen uit 's lands Plantentuin 25 (1898) 1.

[3] De Rochebrune, A. T., Toxicologie Africaine 1 (1897) 431–432.

[4] *Artabotrys odoratissimus* R. Brown is *Artabotrys uncinatus* (Lamarck) Merrill, Enumeration of Philippine Flowering Plants 2 (1923) 173.

[5] Pardo de Tavera, T. H., The Medicinal Plants of the Philippines, by Tavera-Thomas. P. Blakiston's Son and Co., Philadelphia (1901) 20.

EXPERIMENTAL

The material consisted of the bark from the stems and roots of the plant under consideration, as grown in the Philippines. The bark was dried and powdered, and qualitative chemical tests were applied to small portions of the ground material for the possible occurrence of glucosides, saponaceous bodies, and alkaloids. These reveal the presence of an alkaloid. When some sliced pieces of the wood of the stems and roots were tested in the same way, no alkaloid was detected.

A few grams of the sample were treated with 1 per cent aqueous hydrochloric acid and boiled, and the acid liquid evaporated to dryness. The residue was extracted with water and filtered, and the filtrate was concentrated. An aliquot portion of the concentrated extract injected subcutaneously into a guinea pig proved fatal; twelve hours after the administration, the animal died with spasmodic contraction of the muscles and difficulty in respiration as the chief symptoms observed.

In order to determine the relative solubility of the soluble chemical constituents of the bark in various solvents 10 grams of the sample were extracted successively in a Soxhlet apparatus, when the following amounts of extract, dried at 100° C., were obtained:

	Per cent.
Petroleum ether (boiling point, 35°–50°)	0.38
Ether	0.48
Chloroform	1.14
Ethyl acetate	0.52
Alcohol	10.25
Water	2.09
Total extracts	14.86

It was observed that the petroleum ether and the ether extracts are oily and have a fragrant odor. This is presumably due to the volatile oil that is present, especially in the leaves and flowers, in some species of *Artabotrys*. The chloroform extract shows that yellow coloring matter was dissolved by this solvent, while the alcohol extract was found to be resinous. The water extract reduced the Fehling's solution. As a whole, this series of extractions shows that the major portion of the soluble constituents are soluble in alcohol, hence it was used as the solvent in the subsequent extraction for the purpose of isolating the alkaloid.

Several kilograms of the ground material were exhausted by percolation with 85 per cent ethyl alcohol acidified with tartaric acid. The percolate was distilled under diminished pressure until practically all the alcohol had been removed. Steam was then passed into the semisolid extract to remove the volatile substances. The ether extract obtained from the milky distillate is aromatic, but no further tests were made to reveal its nature, as attention was first directed to preparing the alkaloid from the residue that remained in the steam distillation flask. This consisted of a dark brown, aqueous liquid (A), and a considerable quantity of a brown resin (B) which conglomerated into a solid mass as the flask was cooled. This permitted the separation of the aqueous liquid from the resin by decantation. The resin left in the flask was further treated repeatedly with 1 per cent hydrochloric acid until the washing was colorless. The washings were added to the filtered aqueous liquid, and the whole was concentrated and then repeatedly extracted with chloroform which, in this case, was found to be a good solvent for the coloring matter. When an aliquot portion of the greenish yellow chloroform extract was evaporated to dryness and the residue taken up with a few cubic centimeters of dilute hydrochloric acid, it was found to produce copious precipitates with the usual alkaloidal reagents. Therefore, the remaining chloroform solution was distilled under diminished pressure, and the yellowish brown residue was treated with 1 per cent hydrochloric acid, filtered, and the filtrate rendered alkaline with sodium carbonate to liberate the alkaloid. It was then shaken several times with ether, and the ethereal extract on evaporation gave yellowish crystals of the impure alkaloid. In the preliminary purification of the alkaloid the following methods were tried:

1. A small quantity of the impure crystals was dissolved in dilute hydrochloric acid, shaken with ether, and the acid liquid then made alkaline with sodium carbonate. The liberated alkaloid was extracted with ether. This treatment did not remove the color of the alkaloid.

2. Another small portion of the alkaloid was dissolved in dilute hydrochloric acid and then boiled with carbon decolorizer. The color was completely removed, but the decolorizer also absorbed the alkaloid as shown by its absence in the filtrate. An attempt to recover the alkaloid from the decolorizer was not successful.

3. The third method consists of precipitating the alkaloid by means of phosphomolybdic acid, regenerating the alkaloid from the precipitate by sodium hydroxide solution, and shaking the mixture with ether to dissolve the alkaloid. The result was not satisfactory, the alkaloid being still colored.

4. An aliquot portion of the impure alkaloid was redissolved in ether, and the ethereal solution treated with a very small amount of the carbon decolorizer. When the mixture was filtered and the solvent evaporated, it was found that this treatment had removed a considerable amount of the coloring matter.

5. Another small portion of the alkaloid was dissolved in chloroform, and then shaken in the separatory funnel with 5 per cent aqueous sodium hydroxide, which was intended to remove not only the interfering coloring matter but also the phenolic bases if these were present. The chloroform solution after this treatment was washed well with water, and the solvent recovered. Dilute hydrochloric acid was added to the residue, the filtered acid liquid made alkaline with a solution of sodium carbonate, and the mixture shaken with ether. The ethereal solution on evaporation deposited cubical crystals of the alkaloid which were only slightly colored.

As a result of the foregoing preliminary experiments, the remaining amount of the impure alkaloid was dissolved in chloroform and treated repeatedly in a separatory funnel with 5 per cent sodium hydroxide solution until the red color imparted to the alkaline solution was no longer observed. The chloroform solution after being washed with water was distilled under diminished pressure, and the residue left in the flask was dissolved in 1 per cent hydrochloric acid. The alkaloid was freed from its salt by rendering the acid liquid alkaline with sodium carbonate and then was extracted with ether. The ethereal solution was dried with anhydrous calcium chloride, a small quantity of carbon decolorizer was added, and the mixture was filtered. On evaporation of the solvent, fairly pure crystals of the alkaloid were obtained. For further purification of the alkaloid, these crystals were dissolved in a sufficient amount of absolute alcohol, and hydrobromic acid was added. When kept overnight the hydrobromide of the alkaloid was deposited in needlelike crystals which were separated and washed with a little ether. On complete evaporation of the alcohol in the mother liquor at room temperature a further quantity of the

hydrobromide was obtained. The alkaloid, after its regeneration from the crystalline hydrobromide, was dissolved in ether, then a small quantity of purified animal charcoal was added, and the mixture was filtered. On evaporation of the solvent, the alkaloid was obtained in a pure state, occurring in cubical crystals as shown in Plate 1, fig. 1, and having a melting point of 187° C., which remained unaltered even after it was recrystallized from ether. It is proposed to call this alkaloid artabotrine.

The combined sodium hydroxide extract and the alkaline washings from the chloroform solution were acidified with hydrochloric acid. A greenish blue coloring matter was precipitated, which was removed by filtration. The acid filtrate was shaken with chloroform before and after it was made alkaline with sodium carbonate. The two chloroform extracts on evaporation left residues that were not sufficient for testing the presence of phenolic bases.

The original acid aqueous liquid (A), which had been extracted with chloroform, as above described, was treated with phosphomolybdic acid solution and a considerable precipitate was obtained. This was filtered, washed well with water, and decomposed with sodium hydroxide solution. The alkaline solution was then shaken with chloroform several times, and the yellow chloroform solution was treated with 5 per cent aqueous sodium hydroxide, and the alkaloid from the chloroform solution was recovered and purified in the manner already indicated. The pure alkaloid obtained shows the same crystal form, and has the same melting point, as the one recovered from the chloroform extract of the original aqueous liquid.

PROPERTIES OF THE ALKALOID

This base is very soluble in chloroform; fairly soluble in ether, acetone, and ethyl alcohol; sparingly soluble in ethyl acetate, methyl alcohol, and petroleum ether; and practically insoluble in water. It crystallizes from ether in cubical form and from chloroform in radiating tufts of acicular crystals. It has a slightly bitter taste and melts at 187°.

Analysis of the base, dried at 100°:

0.1354 gave 0.3629 CO_2 and 0.1117 H_2O. C = 73.08; H = 9.23.
0.0971 gave 0.2572 CO_2 and 0.0781 H_2O. C = 72.24; H = 9.01.
N = 2.38; 2.36.
$C_{36}H_{55}NO_6$ requires C = 72.36; H = 9.21; N = 2.34; O = 16.08.

The alkaloid is precipitated by the usual alkaloid reagents, and gives the following color reactions: In concentrated sulphuric acid it dissolves to a colorless solution, which on the addition of a trace of nitric acid becomes red, and then yellow. In sulphuric acid containing sugar it produces a pink color changing to reddish violet; while in the same acid but with potassium dichromate a green color is produced. With Fröhde's reagent it gives a dirty green to blue color; while in concentrated nitric acid, it dissolves to red, then greenish yellow, and finally yellow solution. It remains colorless in concentrated hydrochloric acid and in acidified sodium nitrite solution.

A few milligrams of its hydrobromide salt, when injected subcutaneously into a guinea pig, were fatal to the animal. The pronounced external symptoms produced were difficulty in respiration, stretching of the legs, dilatation of the pupil of the eye, and convulsion. In this respect it is very similar to the physiologic action produced by anonaceine as indicated by De Rochebrune.[6]

SUMMARY

The bark of the stem and root of *Artabotrys suaveolens* Blume from the Philippines contains an alkaloid of slightly bitter taste, which is physiologically active.

This alkaloid, which is called artabotrine because of its source, is freely soluble in chloroform; fairly soluble in ether, ethyl alcohol, and acetone; and sparingly soluble in other organic solvents. Its melting point is 187°, and its empirical formula is $C_{36}H_{55}NO_6$.

Artabotrine is precipitated by the usual alkaloidal reagents, and gives color reactions with concentrated nitric acid, Fröhde's reagent, and some oxidizing agents.

It occurs, together with its hydrochloride and hydrobromide salts, in definite crystal forms as shown in Plates 1 and 2.

[6] Toxicologie Africaine 3 (1897) 373.

ILLUSTRATIONS

PLATE 1

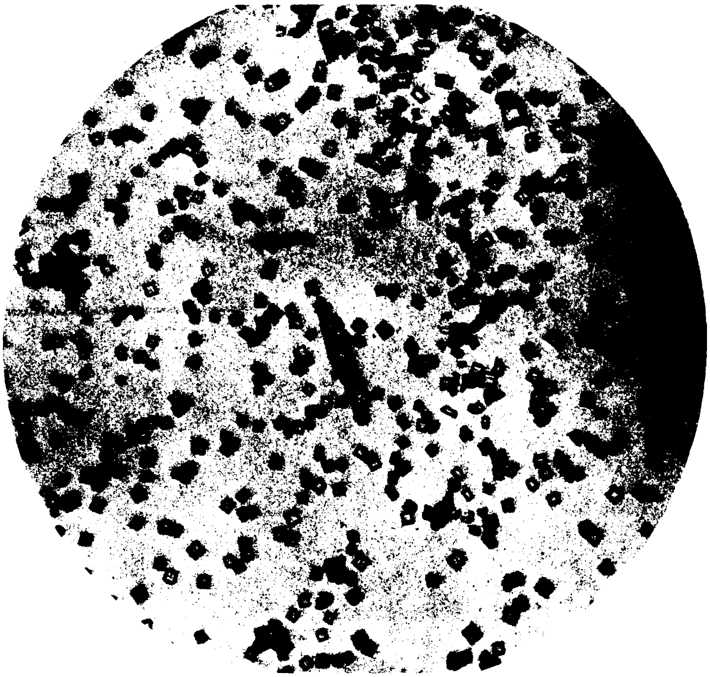
FIG. 1. Cubical crystals of the free alkaloid of *Artabotrys suaveolens* Blume from ether.

2. Radiating tufts of acicular crystals of the same alkaloid, crystallized from chloroform.

PLATE 2

FIG. 3. Featherlike acicular crystals of the hydrochloride of the alkaloid from *Artabotrys suaveolens* Blume.

4. Needlelike crystals of the hydrobromide of the same alkaloid.

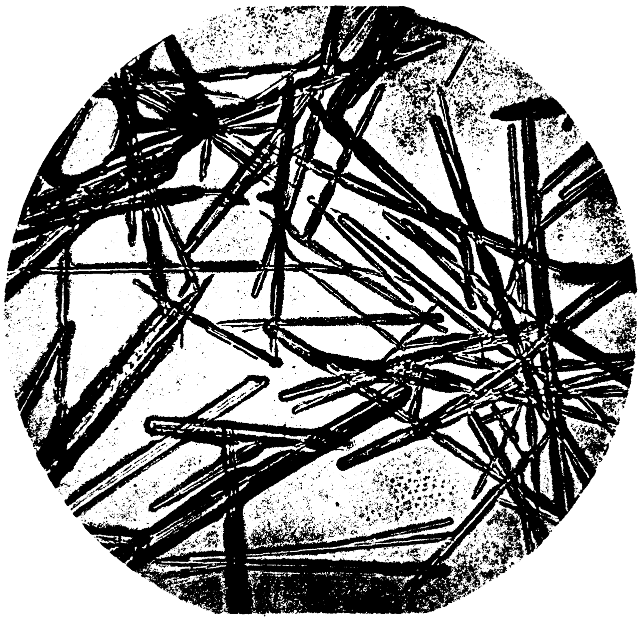


1

2

PLATE 1.

3



4

PLATE 2.

HISTOLOGICAL AND MICROCHEMICAL STUDIES ON THE BARK AND LEAF OF ARTABOTRYS SUAVEOLENS BLUME FROM THE PHILIPPINES

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THREE PLATES

Artabotrys suaveolens Blume of the natural order Anonaceæ, known locally as *susong* damulag, is an interesting plant which, on account of its alkaloidal content, may occupy in the future a prominent place among Philippine medicinal plants, although there is no information regarding its medicinal value in this country. In India, however, it is reported by Watt(6) that the leaves of *Artabotrys suaveolens* afford aromatic medicine which is claimed to be efficacious in inducing reaction during the cold stage of cholera.

Notwithstanding the fact that at present there is nothing known concerning the local medicinal use by the Filipinos of this plant, yet because of the alkaloid found in its bark, which was recently isolated by Dr. Joaquin M. Marañon, the writer believes that *Artabotrys suaveolens* may be considered as one of the most promising Philippine medicinal plants. This is because the plant alkaloids as a rule are physiologically or pharmacologically active substances. It will not be surprising, therefore, if this plant becomes of considerable interest in the future. For this reason this piece of work was undertaken.

Artabotrys suaveolens is a woody climber about 12 meters in length and about 10 centimeters in diameter, with dark longitudinally striated branches and with oblong-lanceolate coriaceous leaves (Plate 1, figs. 1 and 2). According to Merrill,(1) it is found in the Philippines in the following islands: Luzon, Polillo, Mindoro, Palawan, Mindanao, and Basilan, in dry thickets and second-growth forests. In India it occurs through Malaya to the Moluccas.

Interesting accounts regarding the anatomical structures of the leaves of the members of the Anonaceæ, in which *Artabotrys*

suaveolens is included, are reported by Vesque(5) in Nouvelles Archives du Museum. Solereder,(4) who reviewed the work of Vesque and other investigators in the said group, gives the following characters which are very valuable for the recognition of a member of the order: (*a*) The constant occurrence of secretory cells in the leaf parenchyma; (*b*) the almost universal occurrence of solitary or clustered crystals in the epidermis of the leaf; (*c*) the stomatal apparatus with its subsidiary cells arranged parallel to the pore; (*d*) the simple perforations of the vessels; (*e*) the frequent occurrence of diaphragms composed of stone cells in the pith; (*f*) the stratification of the bast into hard and soft bast; (*g*) the absence of external glands.

MATERIAL AND METHODS

The material used for this study was collected September 12, 1927, by Maximo Ramos, collector of the Bureau of Science, from a dry and open forest in the hills or mountains of Antipolo, Rizal Province, Luzon. Of the semidried bark, transverse and radial free-hand sections about 30 to 50 μ thick were prepared. In view of the brown coloration of the cell walls, all the sections were examined without stain in dilute solutions of glycerin and chloral hydrate. Schultze's maceration process as indicated by Greenish(2) was employed in the isolation and study of the individual cell of the bark.

Sections used in the microchemical investigation were all free-hand sections. The following are the reagents used:

Gold chloride, 1 per cent solution.
Palladium chloride, 1 per cent solution.
Platinic chloride, 1 per cent solution.
Wagner's reagent.
Mayer's reagent.
Ferric chloride, 10 per cent solution.
Picric acid, 3 per cent solution.
Alcoholic solution of tartaric acid, 2 per cent.

Sections free from alkaloid were prepared by macerating the sections for about twenty-four hours in a 2 per cent alcoholic solution of tartaric acid, and were washed thoroughly with distilled water before applying the alkaloidal tests.

THE BARK

The dried bark from the main stem is from 5 to 7 millimeters thick, and it may occur in either curved or flat form. The outer surface is somewhat uneven with few transverse and longitu-

dinal fissures, grayish brown to dark brown, and often with whitish- or grayish-green patches of lichens with numerous minute brown perithetia (Plate 1, fig. 3). The inner surface is sepia or dark brown to light brown, longitudinally striated fibrous, and sometimes with some white woody tissue adhering to it. The fracture is tough, somewhat splintery, very fibrous, and incomplete. The fracture surface is brown, uneven, slightly granular near the periphery, and very fibrous in the inner part. The odor is slightly balsamic, and the taste slightly astringent.

The dried bark from the branches is from 1 to 3 millimeters thick and is rather easily separated from the woody cylinder. Externally, it is dark brown, longitudinally striated, and is also frequently covered with grayish white patches of lichens. The inner surface is sepia, finely striated longitudinally, and fibrous. The fracture, like the dried bark from the stem, is tough, fibrous incomplete, and the fracture surface is also granular toward the outer part and fibrous toward the inner side. The odor is also somewhat balsamic, and there is no taste.

The dried root bark is from 3 to 5 millimeters thick, and it occurs in curved or nearly flat pieces. The outer surface is somewhat rough with fine transverse or annular ridges and with slight longitudinal furrows. The outer surface is grayish brown or sometimes reddish brown, while the inner surface is dark brown. The fracture, like that of the stem bark, is tough, incomplete, and fibrous. The fracture surface is light brown, uneven, slightly granular near the periphery, and fibrous in the inner part. The odor is balsamic, and the taste slightly astringent.

Structure of the young bark.—The young bark of *Artabotrys suaveolens* in cross section is rather characteristic in structure, because of the more or less regular distribution of the alternating groups of hard and soft basts in concentric rings and in radial rows. A diagrammatic representation of a portion of a transverse section of a young bark with a small part of the wood cylinder is indicated in Plate 2, fig. 4. The epidermis, as in many plants, consists of a single row of rectangular and tangentially elongated cells with very thick cuticle. These epidermal cells are frequently filled with a brownish red substance. In the longitudinal section they appear axially elongated.

The cortex is composed of seven to ten layers of tangentially elongated parenchyma cells in transverse section and more or less isodiametric in radial section (Plate 2, figs. 5 and 9). These parenchyma cells possess thin and pitted cell walls with brown

coloration. They exhibit well-marked small intercellular spaces, and frequently some of them are filled with a resinous brown substance. Throughout the cortical region near the periphery a few characteristic cells other than parenchyma cells are observed. These are secretion cells, which have a great resemblance to the parenchyma cells, except that they are usually larger and have slightly thicker walls. They are also tangentially elongated in transverse section and somewhat isodiametric in radial section. They measure from 0.035 to 0.050 millimeter in their greatest diameter and from 0.065 to 0.075 millimeter in their smallest diameter in transverse section. Another characteristic of the constituent of the cortex is that the parenchyma cells gradually thicken their walls and become lignified. As a natural consequence of the lignification scattered throughout this region, one may find a few stone cells isolated or in groups. These stone cells are also tangentially elongated. Their walls are distinctly striated and exhibit numerous branching pits. The starch sheath is not distinct.

The pericycle is built up of sclerenchymatous and parenchymatous cells and is not conspicuous. The sclerenchymatous cells are found in small groups in the peripheral parts of the radiating rows of the alternating soft and hard basts. They are more or less polygonal in outline in cross section with fairly thick, lignified, and slightly pitted walls and with very small lumen. Between the groups of sclerenchymatous cells are the tangentially elongated parenchyma cells which connect one group to another. These parenchyma cells have thin, yellow or brown, walls with simple perforations; but as the bark gets older, the walls of some of the cells become thicker, and eventually they develop into stone cells.

Next to the pericycle is the bast ring or bast zone. It is composed of the alternating groups of hard and soft basts arranged in concentric rings and in radial rows (Plate 2, figs. 4, 6, and 7). The layers of both kinds in neighboring groups fit approximately one on another so that they form concentric zones, and traversed and bounded at the lateral parts by two or more cells width consisting of medullary rays. The hard basts consist of very thick-walled cells arranged in tangential rows with polygonal outline in transverse section and with a very greatly reduced cavity or lumen. They are bright yellowish white and not distinctly striated. In the longitudinal section they appear unbranched and tappering at both ends

(Plate 3, fig. 14). They measure about 0.018 millimeter in diameter and about 0.95 millimeter or more in length. The phloëm is composed of sieve tubes, few companion cells, and phloëm parenchyma. The phloëm bundles are frequently surrounded by the bast fibers. This is especially true in the older bark. In the longitudinal section the sieve tubes appear not greatly elongated, and the sieve plates are observed to be more or less in oblique position. The phloëm parenchyma limits the outer part of the sieve tubes and companion cells. They are characterized by their thin brown walls, and are longer than an ordinary parenchyma cell (Plate 2, figs. 6 and 10). The medullary rays exhibit the usual characters; that is, they are radially elongated with thin, pitted, brown or yellow, cell walls (Plate 3, fig. 16). They are commonly from one to four cells wide, and those limiting the outside part of the bundles usually contain calcium oxalate crystals with prismatic or plinorhombic shapes, and the other cells frequently contain a brown substance which is easily soluble in alcohol and water (Plate 2, fig. 10). Some secretion cells are sometimes also found among the medullary cells and in the parenchyma between the bundles.

The older bark.—The older bark is characterized by the presence of the periderm (Plate 2, fig. 7). Its structure is just as complicated as the one above described. For the sake of simplicity, the following will be considered in describing the older bark of *Artabotrys suaveolens;* namely, 1, the periderm; 2, the cortex; 3, the pericycle; 4, the bast zone.

1. The periderm of the bark of *Artabotrys suaveolens* is initiated by the tangential division of the subepidermal cells as is that of *Alstonia scholaris* described by the writer(3) (Plate 3, fig. 12). The only difference between the two is that in the former the phelloderm is not developed while in the latter it is. The periderm of *Artabotrys suaveolens* is thin and is composed of closely fitted and slightly suberized cells, which like some of the parenchyma cells contain a brown substance that is readily soluble in alcohol and water. The phellogen region is not conspicuous.

2. The cortical region is built up of the same elements as those of the young bark, except that in the older bark there is a greater lignification of the cortical parenchyma cells. Throughout this region enormous, hard, thick-walled, sclerenchymatous stone cells are scattered in great numbers. They are found in

large, irregular, light yellow groups. In transverse section of the bark they appear somewhat tangentially elongated and in a radial section, as represented in Plate 2, figs. 8 and 9, they are polygonal in outline. They measure about 0.06 millimeter in diameter and 0.12 millimeter in length. Their walls are stratified, very much thickened, lignified to stony hardness, and perforated by numerous, branched pit canals of circular outline in cross section. When these stone cells are isolated by means of Schultze's maceration process, they display a great diversity of forms and of remarkable shapes and sizes. They vary from a more or less rounded, rectangular, elliptic to a very irregular outline, as represented on Plate 3, fig. 15, *a* to *p*. They are frequently branched at one or both ends. Most of the cortical parenchyma cells in the older bark possess thick and slightly lignified cell walls with simple perforation and brown color. Some of them are filled with a brown substance as are those of some of the younger bark. The parenchyma cells near the periderm, however, when they are isolated appear rounded in form with thin walls, as represented on Plate 3, fig. 13.

3. The pericycle, like that in the younger bark, is very inconspicuous. The sclerenchymatous cells are greatly divided, they appear in a fragmentary form, and are closely located at the outer part of the radiating basts. Between these fragmentary sclerenchymatous elements are tangentially elongated parenchyma cells with slightly stratified cell walls and these frequently become stone cells of various shapes and sizes.

4. The bast zone, like the bast zone of the younger bark, consists of alternating groups of hard and soft basts arranged in concentric rings and split in radial rows by means of the medullary rays. Plate 2, fig. 7, represents a diagrammatic sketch from a camera lucida drawing, showing the alternating arrangement of soft and hard basts, which are traversed by the radiating primary and secondary medullary rays; and fig. 10, on the same plate, is a detailed drawing of a segment from the middle part of a cross section of a bast bundle, while fig. 11, also on Plate 3, indicates the detailed structure of a longitudinal section.

The medullary ray cells of the older bark differ from those of the younger bark in that they have thicker and slightly lignified walls with distinct simple perforation. Frequently, as in the medullary ray cells of the younger bark, some of the medullary cells are filled with a brown substance.

The secretion cells are more numerous in the older bark than in the younger bark. They are found in the cortical parenchyma, in the medullary rays, and in the parenchyma between the basts.

Structure of the root bark.—The structure of the old root bark is analogous to that of the old stem bark. The periderm consists of twelve to fifteen layers of flat, closely fitted, and slightly suberized cells. These cork cells, however, do not contain as much brown material as those of the stem bark. The cortex, like the stem bark consists of tangentially elongated parenchyma cells, but their cell walls are thinner and there is a less degree of lignification. The stone cells are also found scattered throughout the cortical region, but they are fewer in number than those of the same region in the stem bark and the groups are smaller. The endodermis is not observed, and the pericycle is not conspicuous. The sclerenchyma of the pericycle is divided into small groups which are closely adhering to the outer part of the bast bundles. The bast region is very similar to that of the stem bark. It is also traversed by the primary and secondary medullary rays. The medullary cells of the root bark differ from those of the stem bark in that the medullary cells of the root bark have thinner walls. This difference is also observed in the parenchyma cells between the bast bundles in which the parenchyma cells of the root bark have thinner walls and with few stone cells found mixed with them. The secretory cells are also found in the root bark, but these are less numerous than those observed in the stem bark.

Structure of the leaf.—The leaf structure of *Artabotrys suaveolens* in transverse section is bifacial (Plate 3, figs. 17 and 18). The mesophyll has a uniform thickness of about 0.23 millimeter. In the upper epidermis as well as in the lower part is a single layer of large rectangular cells with thick, slightly wavy, and highly cutinized cell walls. Very frequently in the upper and in the lower epidermis some secretory cells containing a grayish white resinous substance are observed (Plate 3, figs. 17 and 19). The palisade chlorenchyma constitutes about the upper one-third of the mesophyll and consists of two rows of tubular and perpendicularly elongated cells. The palisade cells in the upper row are somewhat closely fitted and very much larger than those in the lower row. They measure about 0.012 millimeter in diameter and about 0.05 millimeter in length. Most of them are filled with a brown substance, and

their cell walls are brown. The palisade cells of the lower row are smaller than those of the upper row, and they exhibit large intercellular spaces. The secretion cells are also observed in the palisade region as represented in Plate 3, fig. 18. The spongy chlorenchyma region is well developed, and is frequently limited by a layer of loosely arranged palisade cells in the lower part. It is about twice as thick as the palisade region. The spongy parenchyma cells are of various forms and sizes, and are richly supplied with numerous air spaces. Some of the spongy parenchyma cells, like some of the palisade cells, contain a brown substance. There are no crystalline elements observed in the mesophyll. Epidermal outgrowths are wanting in the material examined; a few are present in the younger leaf. According to Vesque(5) and Solereder,(4) however, the hairy covering of the Anonaceæ consists of simple uniseriate hairs which contain a brown substance. The veins are embedded in the mesophyll. They are surrounded by a single layer of parenchyma cells containing chloroplastids.

The upper as well as the lower epidermal cells in the surface preparations appear polygonal in outline with thick wavy or undulate walls (Plate 3, figs. 20 and 21). The cells of the upper epidermis, however, differ from those of the lower in that the former are larger in size than the latter. The stomata are confined to the lower surface of the leaf; they are characterized by having their subsidiary cells arranged parallel to the pore. Vesque(5) indicates that this is one of the general characteristics of the members of the Anonaceæ.

The midrib is convex above and strongly convex below (Plate 3, fig. 17). The ventral epidermis as well as the dorsal one consists of a single layer of nearly isodiametric or square cells. These cells are remarkable for their very thick cuticle. Occasionally, some secretory cells similar to those observed in the epidermis of the mesophyll are also observed mixed with them. The collenchyma cells above and below the meristele are not very distinct. The angles of their walls at the meeting of three or four cells are not greatly thickened. Many of these cells contain also a brown substance, and their walls are brown.

The cells of the cortical parenchyma have thin walls and are more or less rounded in outline. They consist of two or three rows of cells arranged around the sclerenchyma ring. The endodermis is somewhat distinct.

The meristele is somewhat crescentic or V-shaped. Its outer part is bounded by a sclerenchyma ring, five to seven cells thick. The sclerenchyma cells are bright yellowish white with very thick walls and greatly reduced cavity. The xylem is composed of large and small vessels. The phloëm is found in patches outside of the xylem region, as represented in Plate 3, fig. 17. The phloëm cells, like some of the parenchyma cells, contain a brown substance. The region above the upper central part of the xylem is frequently occupied by stone cells. These stone cells have the same characteristics as those observed in the older stem and root barks.

Microchemical tests and localization of the alkaloid of Artabotrys suaveolens.—This microchemical investigation is confined entirely to the detection of the presence of the alkaloid in the different parts of the plant, and to the determination of the types of tissue in which this alkaloid is located. The different reagents indicated above were used, and the following parts of *Artabotrys suaveolens* were carefully tested microchemically by the said reagents: The young and old stem barks, the old root bark, the wood of young and old stems, the wood of old root, and the leaves.

The free-hand sections were first mounted in a very small amount of distilled water and then treated with the reagents. The results observed from these direct tests were checked or compared with the results of the tests made on the sections freed from the alkaloid; this is done by treating the section first with alcoholic solution of tartaric acid and washing thoroughly with distilled water until no longer acidic before applying the reagents. Similar comparison was made with the results obtained from the reactions of the same reagents to the alcoholic solution of the pure alkaloid. The precipitates produced by the different reagents to the sections containing alkaloid agree quite well, or are more or less similar to the precipitates produced by the same reagents to the alcoholic solution of the pure alkaloid. The solutions of picric acid and ferric chloride, however, behaved differently in the last two comparative tests. The picric acid solution reacts slightly only to the impure alkaloid, or the alkaloid as it occurs in the sections; while in the solution of pure alkaloid it reacts rapidly and gives an abundant yellowish amorphous precipitate. The solution of ferric chloride, on the other hand, reacts rapidly to the alkaloid in the sections, giving an

abundant, amorphous, dark brown or brownish black precipitate, but it reacts very slowly to the alcoholic solution of pure alkaloid and gives a very scanty precipitate.

In all the tests made, the kind of precipitates produced by the different reagents applied to the sections and to the pure solution of alkaloid are the same; that is, they are noncrystalline and are amorphous in nature. From the results of these tests it became evident that the alkaloid is present in the young and the old stem barks and in the old root bark, and is lacking in the wood of both stem and root and in the leaves. In the stem bark, as well as in the root bark, the alkaloid is very abundant in the cortical parenchymatous cells, in the medullary cells, in the parenchyma between the bundles and basts, and in the phloëm parenchyma. It is more abundant in the old barks than in the young ones, and the root bark seems to contain more alkaloid than the stem barks. Plate 3, fig. 24, is a carefully prepared drawing under the camera lucida of a cortical parenchymatous cell from a section treated with gold chloride, showing the characteristic precipitate at the lateral part of the cell, usually clinging to the walls. On the same plate, fig. 23 is a phloëm parenchymatous cell from the same section treated with gold chloride, showing the same kind of precipitate but with few crystals, with more or less polygonal outline, and with brownish black color. The alkaloid present in the medullary cells is relatively smaller in quantity than in the cortical parenchymatous cells and in the phloëm parenchyma as indicated in Plate 3, fig. 25, which was drawn from the same section from which figs. 23 and 24 were taken.

The character of the precipitate produced by the palladium chloride solution to the alkaloid present in the stem bark is analogous to that of the gold chloride solution, except that the granules of the precipitate are smaller. Plate 3, fig. 26, represents a detailed drawing of a cortical parenchymatous cell treated with palladium chloride. The precipitate is amorphous in character and brown in color.

Although the precipitate produced by the solution of platinum chloride is amorphous in character, the granules of the precipitate are relatively larger than those produced by the gold chloride and palladium chloride as represented in Plate 3, figs. 27 and 28.

Wagner's and Mayer's precipitants have produced the same kind of precipitate as the three above-mentioned reagents, but

the reaction is relatively slower. Plate 3, fig. 30, represents a medullary ray taken from the section of a root bark and treated with Wagner's reagent. On fig. 29, on the same plate, is a portion of the precipitate observed from the outside of the section.

According to the relative importance and effectivity of the reagents used, they may be arranged numerically as follows: 1, Gold chloride; 2, palladium chloride; 3, platinum chloride; 4, Wagner's reagent; 5, Mayer's reagent; 6, ferric chloride; 7, picric acid.

SUMMARY

1. The periderm of *Artabotrys suaveolens* is thin and is developed by tangential division of the subepidermal cells.

2. The cortical parenchyma is narrow and composed of thin- or thick-walled parenchymatous cells, secretion cells containing a resinous substance, and stone cells of remarkable shapes and sizes. The stone cells often branch at one or both ends.

3. The pericycle is inconspicuous. The sclerenchymatous cells are found in fragmentary forms located at the outer part of the radiating bast bundles.

4. The bast zone is characterized by the alternating groups of hard and soft basts arranged in concentric rings and radial rows traversed by the medullary rays.

5. Some of the parenchyma cells, as well as some of the medullary cells, the palisade cells, and spongy chlorenchyma cells, are filled with a brown substance that is readily soluble in alcohol and water.

6. Prismatic and clinorhombic calcium oxalate crystals are found packed in the medullary cells.

7. Secretion cells are found not only in cortical parenchyma, but also in the medullary rays and in the upper and the lower part of the leaf.

8. The leaf in cross section is bifacial, and the upper and the lower epidermis consist of a single layer of cells. The mesophyll is composed of one or two rows of palisade chlorenchyma in the upper part and spongy chlorenchyma in the lower part, and frequently with a layer of short palisade cells below.

9. The stomata are found in the lower surface only and are characterized by the parallel arrangement of their subsidiary cells to the pore. Epidermal outgrowth is not observed.

10. The cross section of the midrib displays poorly developed collenchyma cells in the upper and the lower parts, a narrow parenchyma region, a thick sclerenchyma ring surrounding the V-shaped meristele, and frequently with stone cells in the pith.

11. Microchemical tests proved that the alkaloid of *Artabotrys suaveolens* is located in the stem and the root barks and is lacking in the wood and the leaf. It is found in the cortical parenchyma, the medullary cells, and the phloëm parenchyma. It is relatively more abundant in the cortical parenchyma than in the other types of tissues, and there is a greater amount of alkaloid in the root bark than in the stem bark.

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ILLUSTRATIONS

[All microscopic drawings by the author. Figures 1 and 2 by F. Gatmaitan, Bureau of Science. Photograph on Plate 1, by J. Redondo, Department of Botany, University of the Philippines.]

PLATE 1. ARTABOTRYS SUAVEOLENS BLUME

FIG. 1. A habit sketch of a portion of the plant. × 0.5.
2. An inflorescence with a curved peduncle and one mature flower. × 1.
3. A photograph of young and old stem barks, *a–e*.

PLATE 2. ARTABOTRYS SUAVEOLENS BLUME

FIG. 4. Diagrammatic drawing of a transverse section of young stem bark with a portion of wood adhering to it; *sc*, stone cell; *s*, secretion cell; *scl*, sclerenchyma cell; *sb*, soft bast; *hb*, hard bast; *c*, cambium; *w*, wood; *v*, vessel. × 40.
5. A portion of the cortical parenchyma from the transverse section of a young stem bark; *s*, secretion cell; *sc*, stone cells; *scl*, sclerenchyma cells. × 200.
6. A portion of the bast region from the transverse section of a young stem bark; *scl*, sclerenchyma cells; *p*, parenchyma cells; *ph*, phloëm; *bf*. bast fibers. × 200.
7. Diagrammatic drawing of a transverse section of an old stem bark; *p*, periderm; *sc*, stone cells; *scl*, sclerenchymatous cells; *mr*, medullary rays; *sb*, soft bast; *hb*, hard bast. × 10.
8. A portion of the cortical parenchyma from the transverse section of an old stem bark; *p*, parenchyma cells; *pw*, parenchyma cells with thick pitted walls; *co*, calcium oxalate crystal; *sc*, stone cells. × 200.
9. A portion of the cortical parenchyma from a radial section of an old stem bark; *sc*, stone cells; *p*, parenchyma cells; *pw*, parenchyma cells with cell walls becoming lignified. × 185.
10. A small portion of a bast bundle from a transverse section of an old stem bark; *st*, sieve tubes; *p*, phloëm parenchyma; *co*, calcium oxalate crystal; *mr*, medullary cells. × 185.

PLATE 3. ARTABOTRYS SUAVEOLENS BLUME

FIG. 11. A small portion of an oblique radial section of bast bundle; *bf*, bast fiber; *ph*, phloëm, *php*, phloëm parenchyma; *co*, calcium oxalate crystals; *mr*, medullary cells with thickened and pitted cell walls. × 300.
12. A portion of a transverse section cut through the cortical region showing the first tangential division of the subepidermal cells for the development of the periderm; *p*, phellogen. × 500.

FIG. 13. A group of cortical parenchyma cells isolated by Schultze's maceration process. × 300.

14. A group of bast fibers. × 70.

15. Sclerenchymatous stone cells isolated by Schultze's maceration process, *a–p*. × 100.

16. Isolated medullary ray cells from an old stem bark. × 300.

17. Diagrammatic transverse section of a leaf; *s*, secretion cell; *c*, collenchyma cells; *scl*, sclerenchyma ring; *sc*, stone cells; *ph*, phloëm. × 45.

18. A portion of a transverse section of a leaf blade; *s*, secretion cell; *bs*, parenchyma cells containing brown substance. × 185.

19. A very small portion of the upper epidermis near the midrib showing secretion cell, *c*. × 300.

20. Surface view of a small area of the upper epidermis of the leaf. × 200.

21. Surface view of a small area of the lower epidermis of the leaf. × 200.

22. A cortical parenchyma cell from the stem bark showing the nature of precipitate of the alkaloid treated with ferric chloride. × 500.

23. A phloëm parenchyma cell from the stem bark with alkaloidal precipitate of gold chloride. × 500.

24. A cortical parenchyma cell from the stem bark with alkaloidal precipitate of gold chloride. × 500.

25. A medullary cell from the stem bark with alkaloidal precipitate of gold chloride. × 500.

26. A parenchyma cell from the stem bark with alkaloidal precipitate of palladium chloride. × 500.

27. A medullary cell from the stem bark with alkaloidal precipitate of platinic chloride. × 500.

28. Small amount of the precipitate outside of the transverse section of stem bark treated with platinum chloride. × 500.

29. Small amount of precipitate outside of the transverse section of root bark treated with Wagner's reagent. × 500.

30. A cortical parenchyma cell from the root bark with alkaloidal precipitate of Wagner's reagent. × 500.

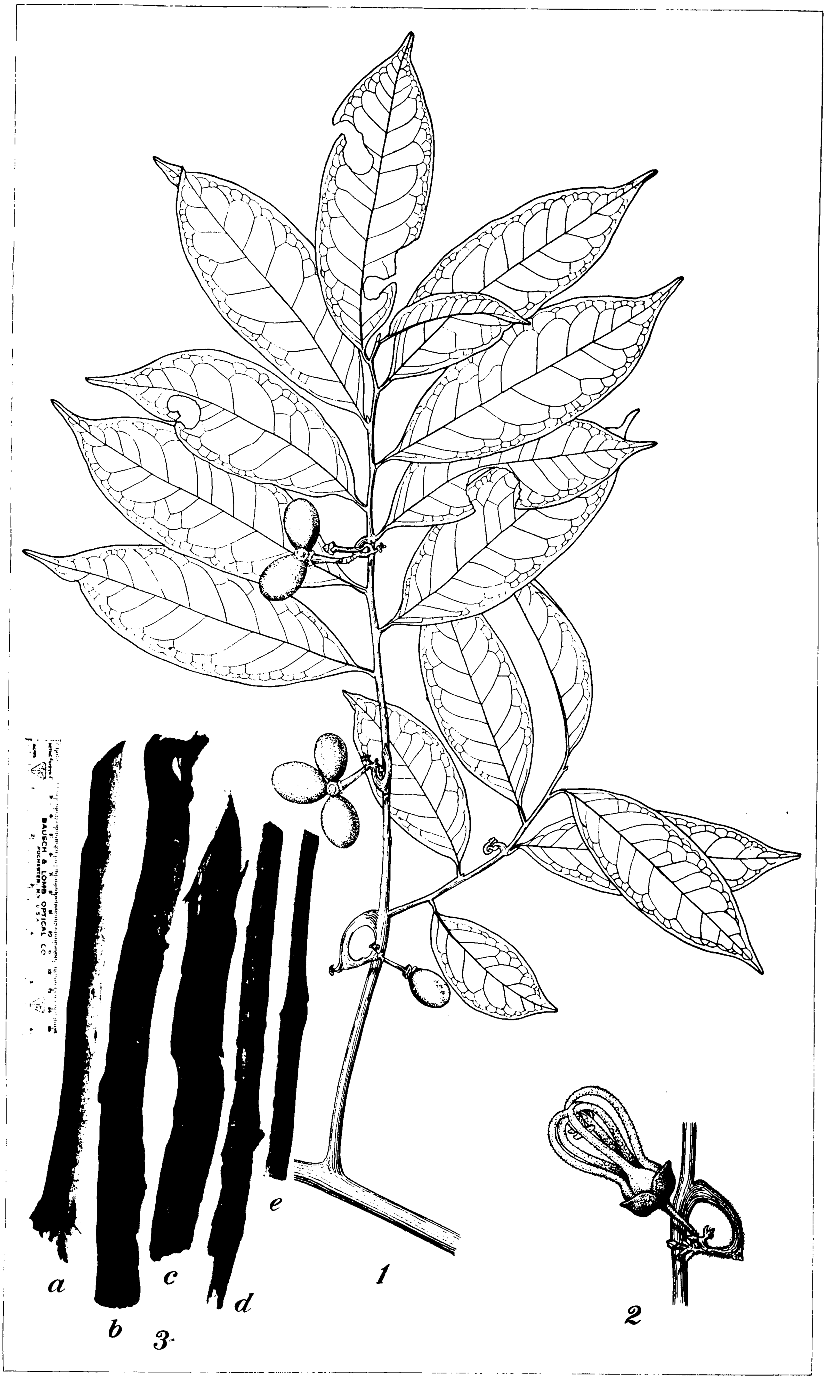

PLATE 1.

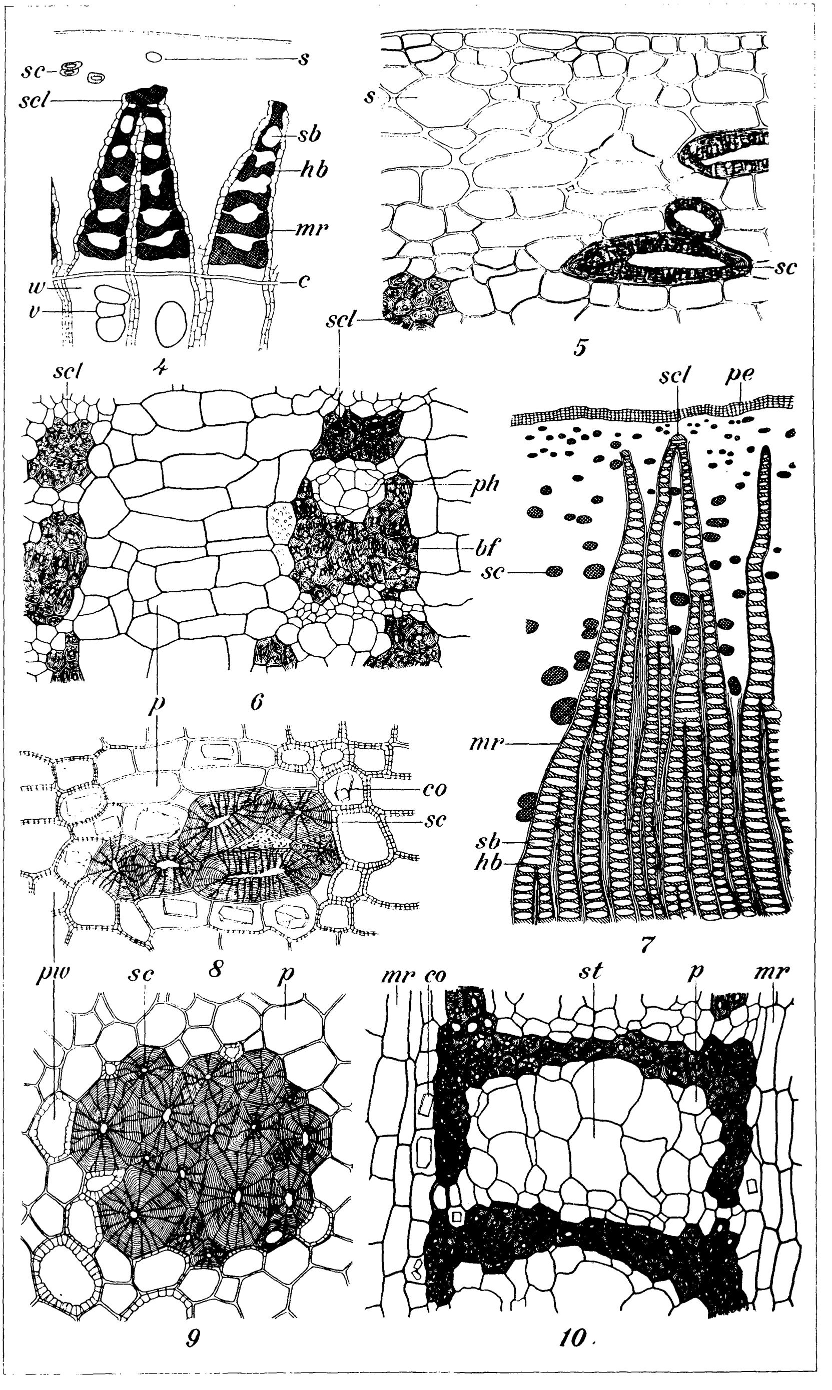
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PLATE 2.

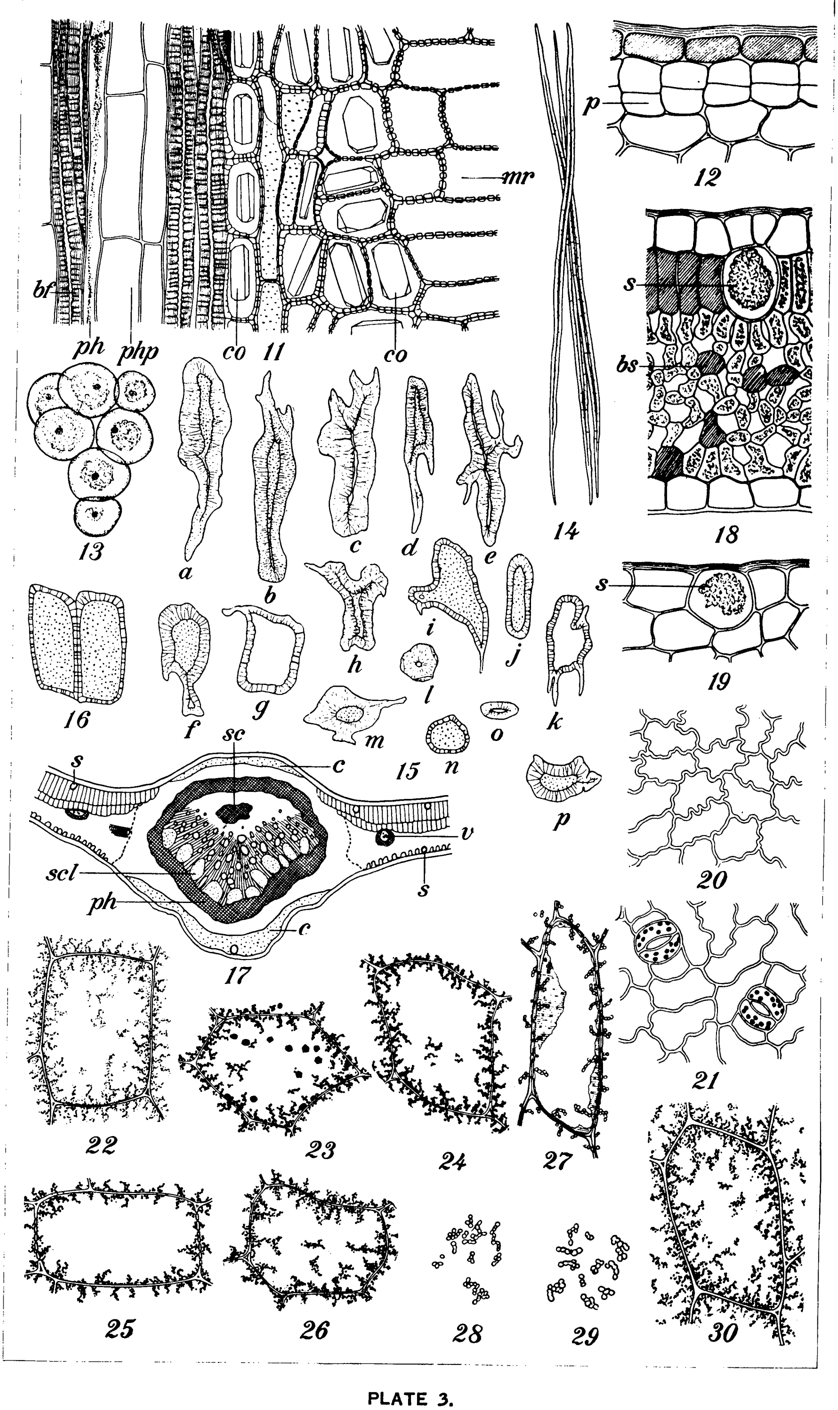
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PLATE 3.

FRESH-WATER DIATOMS FROM KOREA, JAPAN

By B. W. Skvortzow

Of Harbin, China

ONE PLATE

So far as I know, no previous account of the fresh-water algæ of Korea has been published, and the present investigation thus affords the first available data on this subject.

I consider it of great advantage that so competent a scientist as Prof. Tamezo Mori, of the Imperial University of Seoul, who has added much to the knowledge of the Korean flora, undertook the collection of these samples. All of Professor Mori's algæ were collected in the lake at Seiriori near Seoul between March and July, 1926.

The diatoms collected by Professor Mori number 87, among which were the following new forms:

Eunotia bicapitata Grun. var. *koreana* var. nov.
Neidium affine Ehrenb. var. *genuina* Cleve f. *koreana* f. nov.
Neidium preschevalski Skv. var. *koreana* var. nov.
Navicula pupula Kütz. var. *koreana* var. nov.
Navicula lanceolata (Ag.) Kütz. var. *koreana* var. nov.
Navicula rhynchocephala Kütz. var. *hankensis* Skv. f. *koreana* f. nov.
Pinnularia bogotensis Grun. var. *koreana* var. nov.
Pinnularia subcapitata Greg. f. *koreana* f. nov.
Pinnularia interrupta W. Sm. var. *koreana* var. nov.
Gomphonema morii sp. nov.
Cymbella koreana sp. nov.
Cymbella lanceolata Ehrenb. var. *koreana* var. nov.
Cymbella lanceolata Ehrenb. var. *pantocseki* var. nov.

MELOSIRA ITALICA (Ehrenb.) Kütz. subsp. SUBARCTICA O. Müll.

Length, 0.0238 mm; breadth, 0.0085.

MELOSIRA GRANULATA (Ehrenb.) Ralfs var. ANGUSTISSIMA O. Müll.

Length, 0.0255 mm; breadth, 0.0051.

TABELLARIA FENESTRATA (Lynb.) Kütz.

TABELLARIA FLOCCULOSA Kütz.

FRANGILARIA HARRISSONI (W. Sm.) Grun.

SYNEDRA ULNA (Nitzsch.) Ehrenb.

Length, 0.12 to 0.117 mm; breadth, 0.0058; striæ, 9 to 10 in 0.01 mm.

SYNEDRA ACUS Kütz.

Length, 0.195 mm; breadth, 0.00348; striæ, 8 in 0.01 mm.

SYNEDRA FAMILIARIS Kütz. Plate 1, fig. 30.

Length, 0.0544 mm; breadth, 0.0025; striæ, 15 in 0.01 mm.

ACTINELLA BRASILIENSIS Grun. Plate 1, fig. 1.

Length, 0.119 mm; breadth, 0.0136; striæ, 15 in 0.01 mm.

ACTINELLA BRASILIENSIS Grun. var. CURTA Skv. Plate 1, fig. 2.

Length, 0.054 to 0.0663 mm; breadth, 0.0085; striæ, 14 in 0.01 mm. Known only in Hanka Lake.

EUNOTIA LUNARIS Ehrenb.

Length, 0.14 mm; breadth, 0.004 mm; striæ, 14 in 0.01 mm.

EUNOTIA LUNARIS Ehrenb. var. SUBARCTICA Grun.

Length, 0.051 m; breadth, 0.0041; striæ, 15 in 0.01 mm.

EUNOTIA GRACILIS Ehrenb.

Length, 0.0765 mm; breadth, 0.003; striæ, 13 to 14 in 0.01 mm.

EUNOTIA PECTINALIS Kütz. var. MINOR Kütz.

Length, 0.0306 to 0.0357 mm; breadth, 0.0042 to 0.005; striæ, 12 in 0.01 mm.

EUNOTIA ROBUSTA Ralfs. Plate 1, fig. 3.

Length, 0.078 to 0.1071 mm; breadth, 0.013 to 0.0153; striæ, 11 to 14 in 0.01 mm.

EUNOTIA BICAPITATA Grun. var. KOREANA var. nov. Plate 1, fig. 4.

Frustulis 0.1366 ad 0.17 mm longis, 0.0042 mm latis; striæ 14 in 0.01 mm ad polis capitatis.

COCCONEIS PLACENTULA Ehrenb.

ACHNANTHFS HUNGARICA Grun.

Length, 0.0272 mm; breadth, 0.0082.

ACHNANTHES EXIGUA Grun.

Length, 0.011 mm; breadth, 0.0051.

NEIDIUM AFFINE Ehrenb. var. GENUINA Cleve f. MINOR Cleve. Plate 1, fig. 5.

Length, 0.0527 to 0.0884 mm; breadth, 0.007 to 0.012; striæ, 20 to 22 in 0.01 mm.

NEIDIUM AFFINE Ehrenb. var. **GENUINA** Cleve f. **KOREANA** f. nov. Plate 1, fig. 6.

Valvis robustris cum polis subcapitatis, 0.175 mm longis, 0.0306 mm latis; striæ 17 in 0.01 mm.

NEIDIUM PRESCHEVALSKI Skv. var. **KOREANA** var. nov. Plate 1, figs. 7 and 8.

Valvis elongatis cum polis obtusis, 0.0782 ad 0.102 mm longis, 0.017 ad 0.0187 mm latis; striæ 15 ad 18 in 0.01 mm.

Typical *N. preschevalski* is found in Hanka Lake in Primorsk Province.

STAURONEIS ANCEPS Ehrenb.

Length, 0.0255 mm; breadth, 0.0051; striæ, 30 in 0.01 mm.

STAURONEIS ANCEPS Ehrenb. var. **BIROSTRIS** Ehrenb.

Length, 0.0493 to 0.0595 mm; breadth, 0.012; striæ, 20 in 0.01 mm.

STAURONEIS ANCEPS Ehrenb. var. **AMPHICEPHALA** (Kütz.) Cleve.

Length, 0.0629 mm; breadth, 0.0105.

STAURONEIS ANCEPS Ehrenb. var. **ORIENTALIS** Skv. forma. Plate 1, fig. 9.

Length, 0.0952 mm; breadth, 0.0223; striæ, 30 in 0.01. Hanka Lake.

STAURONEIS PHOENICENTERON Ehrenb.

Length, 0.1115 to 0.1445 mm; breadth, 0.024 to 0.025; striæ, 13 to 15 in 0.01 mm.

STAURONEIS PHOENICENTERON Ehrenb. var. **GENUINA** Cleve. Plate 1, fig. 11.

Length, 0.167 mm; breadth, 0.034; striæ, 14 in 0.01 mm.

STAURONEIS PHOENICENTERON Ehrenb. var. **HANKENSIS** Skv. forma. Plate 1, 13.

Valvis 0.153 mm longis, 0.0322 mm latis; striæ 13 in 0.01 mm.

FRUSTULA RHOMBOIDES (Ehrenb.) Cleve.

Length, 0.057 mm; breadth, 0.0136; striæ, 30 in 0.01 mm.

NAVICULA PUPULA Kütz. var. **KOREANA** var. nov. Plate 1, fig. 12.

Valvis elongatis cum polis attenuatis et rotundatis, 0.0289 mm longis, 0.0076 mm latis. Area axillaris angusta linearis, centralis ad forman vittæ minoris dilatate transverse; striæ subradiantes 15 in 0.01 mm.

NAVICULA ANGLICA Ralfs. var. **MINUTA** Cleve.

Length, 0.0187 mm; breadth, 0.0076; striæ, 14 in 0.01 mm.

NAVICULA LANCEOLATA (Ag.) Kütz.

Length, 0.0272 to 0.0357 mm; breadth, 0.0051 to 0.0068; striæ, 15 to 18 in 0.01 mm.

NAVICULA LANCEOLATA (Ag.) Kütz. var. KOREANA var. nov. Plate 1, fig. 14.

Valvis productis, longioribus et rostratis, 0.0646 mm longis, 0.0136 mm latis; striæ 12 ad 14 in 0.01 mm.

NAVICULA PEREGRINA Ehrenb. var. MENISCUS Schum.

Length, 0.0357 mm; breadth, 0.009.

NAVICULA RHYNCHOCEPHALA Kütz. var. HANKENSIS Skv. f. KOREANA f. nov. Plate 1, fig. 23.

Valvis cum polis non capitatis, 0.0323 mm longis, 0.0085 mm latis; striæ 15 in 0.01 mm.

NAVICULA CUSPIDATA Kütz.

Length, 0.1122 mm; breadth, 0.0255; striæ, 15 in 0.01 mm.

NAVICULA ROTAEANA (Rabenh.) V. Heurck.

Length, 0.0272 mm; breadth, 0.0088.

NAVICULA BACILLIFORMIS Grun.

Length, 0.0391 mm; breadth, 0.0102; striæ, 15 in 0.01 mm.

NAVICULA PUPULA Kütz. var. RECTANGULARIS Grun.

Length, 0.0425 mm; breadth, 0.0102; striæ, 18 to 20 in 0.01 mm.

NAVICULA AMERICANA Ehrenb. Plate 1, fig. 15.

Length, 0.0748 mm; breadth, 0.0165; striæ, 18 in 0.01 mm.

PINNULARIA BOGOTENSIS Grun. Plate 1, fig. 16.

Length, 0.102 mm; breadth, 0.0136; striæ, 8 in 0.01 mm.

PINNULARIA BOGOTENSIS Grun. var. KOREANA var. nov. Plate 1, fig. 17.

Valvis directis attenuatis cum polos obtusis et rotundatis, 0.0867 mm longis, 0.0085 mm latis. Area axillaris leniter dilatata, centralis rotundata; striæ 12 ad 13 in 0.01 mm. Subradiantes ordinatis.

PINNULARIA MAJOR Kütz.

Length, 0.184 mm; breadth, 0.028.

PINNULARIA MAJOR Kütz. var. LINEARIS Cleve.

Length, 0.177 mm; breadth, 0.02.

PINNULARIA GENTILIS Donk.

Length, 0.177 mm; breadth, 0.0255; striæ, 7 in 0.01 mm.

PINNULARIA ACROSPHAERIA Bréb.

Length, 0.0578 mm; breadth, 0.011; striæ, 14 in 0.01 mm.

PINNULARIA VIRIDIS Nitzsch.

Length, 0.1139 mm; breadth, 0.0187; striæ, 7 in 0.01 mm.

PINNULARIA VIRIDIS Nitzsch. var. FALLAX Cleve.

Length, 0.051 mm; breadth, 0.011; striæ, 9 in 0.01 mm.

PINNULARIA MAJOR (Kütz.) Rabenh. var. SUBACUTA (Ehrenb.) Cleve f. SUBCONSTRICTA A. Mayer. Plate 1, fig. 18.

Length, 0.0452 mm; breadth, 0.017; striæ, 7 in 0.01 mm.

PINNULARIA TABELLARIA Ehrenb.

Length, 0.222 mm; breadth, 0.024.

PINNULARIA STAUROPTERA (Grun.) Rabenh. var. INTERRUPTA Cleve.

Length, 0.13 to 0.1326 mm; breadth, 0.0153; striæ, 9 in 0.01 mm.

PINNULARIA LATA Bréb. var. MINOR Grun. Plate 1, fig. 24.

Length, 0.0408 mm; breadth, 0.012; striæ, 5 in 0.01 mm.

PINNULARIA BOREALIS Ehrenb. var. GENUINA A. Mayer.

Length, 0.0408 mm; breadth, 0.0102 mm; striæ, 6 to 6.5 in 0.01 mm.

PINNULARIA LEGUMEN Ehrenb. Plate 1, fig. 29.

Length, 0.0935 mm; breadth, 0.0187; striæ, 9 in 0.01 mm.

PINNULARIA SUBCAPITATA Greg. f. KOREANA f. nov. Plate 1, fig. 32.

Valvis 0.0493 ad 0.051 mm longis, 0.01 ad 0.0118 mm latis; striæ, 9 ad 11 in 0.01 mm.

PINNULARIA MESOLEPTA Ehrenb.

Length, 0.0473 mm; breadth, 0.009; striæ, 10 in 0.01 mm.

PINNULARIA MESOLEPTA Ehrenb. var. STAURONEIFORMIS Grun. Plate 1, fig. 27.

Length, 0.0629 mm; breadth, 0.009; striæ, 10 in 0.01 mm.

PINNULARIA INTERRUPTA W. Sm. f. STAURONEIFORMIS Cleve forma.

Length, 0.0408 mm; breadth, 0.006; striæ, 10 in 0.01 mm.

PINNULARIA INTERRUPTA W. Sm. var. KOREANA var. nov. Plate 1, fig. 25.

Valvis curtis cum polis attenuatis, 0.0289 mm longis, 0.0068 mm latis. Area axillaris lanceolata ad porum centralem transverse dilatate. Striæ subradiantes, 12 in 0.01 mm.

PINNULARIA INTERRUPTA W. Smith var. GENUINA A. Mayer.

Length, 0.0612 mm; breadth, 0.0085.

PINNULARIA BRAUNII Grun. Plate 1, fig. 26.

Length, 0.0442 mm; breadth, 0.008; striæ, 12 in 0.01 mm.

GOMPHONEMA SPHAEROPHORUM Ehrenb.

Length, 0.0442 mm; breadth, 0.068 to 0.085; striæ, 12 to 14 in 0.01 mm.

GOMPHONEMA ACUMINATUM Ehrenb. f. **CORONATA** Ehrenb.

Length, 0.051 to 0.074 mm; breadth, 0.012 to 0.014; striæ, 8 to 10 in 0.01 mm.

GOMPHONEMA ACUMINATUM Ehrenb. var. **TURRIS** Ehrenb. Plate 1, fig. 28.

Length, 0.0629 to 0.0935 mm; breadth, 0.011 to 0.0153; striæ, 8 to 10 in 0.01 mm.

GOMPHONEMA AUGUR Ehrenb.

Length, 0.0374 to 0.0527 mm; breadth, 0.09 to 0.01; striæ, 10 in 0.01 mm.

GOMPHONEMA CONSTRICTUM Ehrenb.

Length, 0.0323 to 0.0442 mm; breadth, 0.012 to 0.013; striæ, 9 in 0.01 mm.

GOMPHONEMA GRACILE Ehrenb. var. **AURITA** Al. Br.

Length, 0.034 mm; breadth, 0.0051; striæ, 13 in 0.01 mm.

GOMPHONEMA PARVULUM Kütz. var. **MICROPUS** Kütz.

Length, 0.034 mm; breadth, 0.0051 mm; striæ, 12 in 0.01 mm.

GOMPHONEMA OLIVACEUM Lyngb. var. **TENELLUM** Kütz.

Length, 0.0221 mm; breadth, 0.0051; striæ, 15 in 0.01 mm.

GOMPHONEMA MORII sp. nov. Plate 1, fig. 31.

Valvis lanceolatis cum polis productis et acuminatis, 0.034 ad 0.0425 mm longis, 0.006 ad 0.0065 mm latis; striæ subtilis 20 ad 22 in 0.01 mm. Area axillaris distincta, centralis dilatata.

Named in honor of Prof. Tamezo Mori, who found this form.

CYMBELLA ASPERA Ehrenb.

Length, 0.136 to 0.173 mm; breadth, 0.0272 to 0.0306; striæ, 8 in 0.01 mm.

CYMBELLA TUMIDA Bréb.

Length, 0.051 mm; breadth, 0.0153; striæ, 9 in 0.01 mm.

CYMBELLA TUMIDA Bréb. var. **BOREALIS** Grun.

Length, 0.0724 mm; breadth, 0.0187; striæ, 9 to 10 in 0.01 mm.

CYMBELLA VENTRICOSA Kütz.

Length, 0.0493 mm; breadth, 0.0136; striæ, 9 in 0.01 mm.

CYMBELLA NAVICULIFORMIS Auersw.

Length, 0.0408 mm; breadth, 0.012; striæ, 15 in 0.01 mm.

CYMBELLA GRACILIS Rabenh.

Length, 0.0357 to 0.0595 mm; breadth, 0.0055 to 0.0085 mm; striæ, 9 to 13 in 0.01 mm.

CYMBELLA KOREANA sp. nov. Plate 1, figs. 20 to 22.

Valvis 0.263 mm longis, elongatis, cymbiformibus, polos versus attenuatis cum polis rotundatis obtusis, ad medium valvæ magis inflatis et hic usque ad 0.0323 mm dilatatis; rhaphe leniter arcuata, a zona hyalina nuda, tandem ad nodulum centralem dilatata, area ad ventrem plica uniceraliter punctate et plica nuda notata. Striis subradiantibus 9 in 0.01 mm.

CYMBELLA LANCEOLATA Ehrenb. var. KOREANA var. nov. Plate 1, fig. 18.

Valvis lanceolatis cum polis productis, ventre concavis, 0.248 mm longis, 0.0357 mm latis; striæ, 8 ad 9 in 0.01 mm.

CYMBELLA LANCEOLATA Ehrenb. var. PANTOCSEKI var. nov. Plate 1, fig. 19.

Egrege var. longissima Pant., valvis elongatis cymbiformibus cum polis obtusis, ad ventrem leniter inflatis, 0.27 mm longis, 0.0323 mm latis; striæ, 8.5 in 0.01 mm.

RHOPOLODIA GIBBA (Ehrenb.) O. Müll.

Length, 0.0901 to 0.1615 mm; breadth, 0.0204 to 0.0255 mm; striæ, 7 to 8 in 0.01 mm.

RHOPOLODIA VENTRICOSA (Grun.) O. Müll.

Length, 0.0612 mm; breadth, 0.018; striæ, 9 in 0.01 mm.

NITZSCHIA SUBTILIS (Kütz.) Grun. var. INTERMEDIA (Hantzsch.) Schönf.

Length, 0.0748 to 0.0986 mm; breadth, 0.0051 to 0.0068; striæ, coarse, 8 or 9 in 0.01 mm; fine, 25 in 0.01 mm.

NITZSCHIA FRUSTULUM (Kütz.) Grun.

Length, 0.0187 mm; breadth, 0.0022; striæ, 12 in 0.01 mm.

HANTZSCHIA AMPHIOXYS (Ehrenb.) var. XEROPHILA Grun.

Length, 0.0323 mm; breadth, 0.0051; striæ, 8 in 0.01 mm.

SURIRELLA SPLENDIDA (Ehrenb.) Kütz. var. GENUINA A. Mayer.

Length, 0.1785 mm; breadth, 0.0459.

SURIRELLA APICULATA Hustedt.

Length, 0.0391 to 0.0561 mm; breadth, 0.009 to 0.012; striæ, 5 or 6 in 0.01 mm.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Actinella brasiliensis* Grun.
2. *Actinella brasiliensis* Grun. var. *curta* Skv.
3. *Eunotia robusta* Ralfs.
4. *Eunotia bicapitata* Grun. var. *koreana* var. nov.
5. *Neidium affine* Ehrenb. var. *genuina* Cleve f. *minor* Cleve.
6. *Neidium affine* Ehrenb. var. *genuina* Cleve f. *koreana* f. nov.

FIGS. 7 and 8. *Neidium prechevalski* Skv. var. *koreana* var. nov.

FIG. 9. *Stauroneis anceps* Ehrenb. var. *orientalis* Skv. forma.
10. *Cymbella lanceolata* Ehrenb. var. *koreana* var. nov.
11. *Stauroneis phoenicenteron* Ehrenb. var. *genuina* Cleve.
12. *Navicula pupula* Kütz. var. *koreana* var. nov.
13. *Stauroneis phoenicenteron* Ehrenb. var. *hankensis* Skv. forma.
14. *Navicula lanceolata* (Ag.) Kütz. var. *koreana* var. nov.
15. *Navicula americana* Ehrenb.
16. *Pinnularia bogotensis* Grun.
17. *Pinnularia bogotensis* Grun. var. *koreana* var. nov.
18. *Pinnularia major* (Kütz.) Rabenh. var. *subacuta* (Ehrenb.) Cleve f. *subconstricta* A. Mayer.
19. *Cymbella lanceolata* Ehrenb. var. *pantocseki* var. nov.

FIGS. 20, 21, and 22. *Cymbella koreana* sp. nov.

FIG. 23. *Navicula rhynchocephala* Kutz. var. *hankensis* Skv. f. *koreana* f. nov.
24. *Pinnularia lata* Bréb. var. *minor* Grun.
25. *Pinnularia interrupta* W. Sm. var. *koreana* var. nov.
26. *Pinnularia braunii* Grun.
27. *Pinnularia mesolepta* Ehrenb. var. *stauroneiformis* Grun.
28. *Gomphonema acuminatum* Ehrenb. var. *turris* Ehrenb.
29. *Pinnularia legumen* Ehrenb.
30. *Synedra familiaris* Kütz.
31. *Gomphonema morii* sp. nov.
32. *Pinnularia subcapitata* Greg. f. *koreana* f. nov.

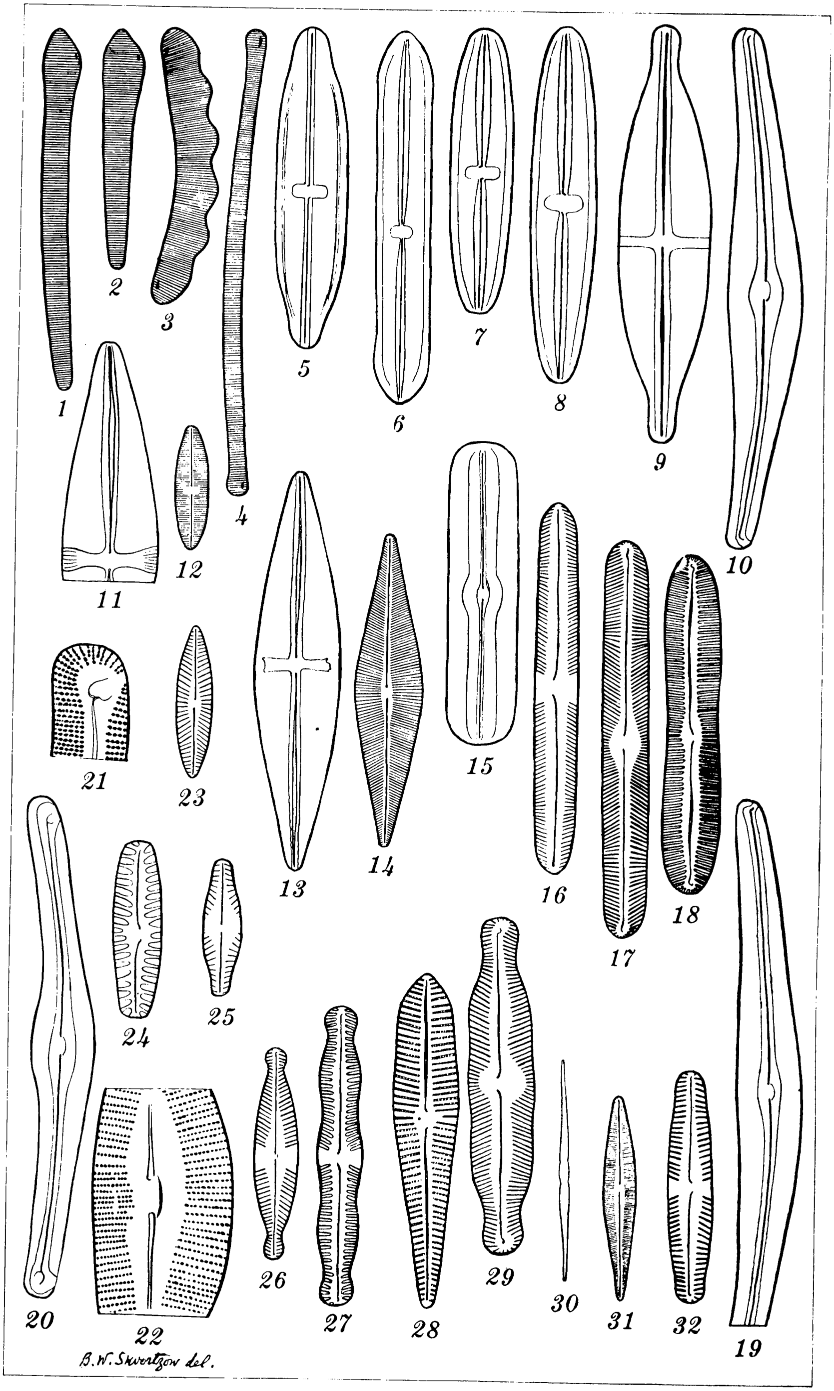
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PLATE 1.

CHAULMOOGRYL SUBSTITUTED PHENOLS AND CHAULMOOGRYL HYDROXY ETHYL BENZOATE

By IRENE DE SANTOS and AUGUSTUS P. WEST

Of the Bureau of Science, Manila

Various derivatives of chaulmoogric acid, such as esters and anilides, have been made from chaulmoogra oil.[1] In the present investigation, a few chaulmoogryl substituted phenols and also chaulmoogryl *m*-hydroxy ethyl benzoate were prepared. The method of preparation consisted in treating the acid chloride of chaulmoogric acid with the substituted phenols. The results seem to indicate that these compounds may be prepared somewhat easily though some of the reactions take place rather slowly. The new compounds prepared in this research will be tested for their therapeutic value. In order to check the formulas of the dihalogen phenol esters, the halogen content was determined. A modified combustion method[2] for the determination of bromine in organic compounds was employed for making the halogen analysis.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was kindly presented to us by Dr. H. I. Cole, of the Philippine Bureau of Health, and was shipped directly to us from the Culion Leper

[1] Power, F. B., and F. H. Gornall, Journ. Chem. Soc. Trans. **85** (1904) 838 and 851.—Power, F. B., and M. Barrowcliff, Journ. Chem. Soc. Trans. **91**, 1 (1907) 557.—Shriner, R. L., and Roger Adams, Journ. Am. Chem. Soc. 47 (1925) 2727.—Perkins, G. A., Philip. Journ. Sci. **24** (1924) 621.—Perkins, G. A., and A. O. Cruz, Journ. Am. Chem. Soc. **49** (1927) 1070.—Perkins, G. A., Journ. Am. Chem. Soc. **48** (1926) 1714.—Van Dyke, R. H., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 2393.—Sacks, J., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 2395.—Dean, A. L., R. Wrenshall, and G. Fujimoto, Journ. Am. Chem. Soc. **47** (1925) 403.—Noller, C. R., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 1080.—Herrera-Batteke, P. P., and A. P. West, Philip. Journ. Sci. **31** (1926) 161.—Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265; **35** (1928) 405.

[2] Smith, F. L., Philip. Journ. Sci. **32** (1927) 315.

Colony. The oil was prepared from the seeds of *Hydnocarpus alcalæ* C. de Candolle.

The chaulmoogric acid and acid chloride of chaulmoogric acid were prepared according to the procedure used by Santiago and West.[3] Chaulmoogra oil (600 grams) was saponified with alcoholic potassium hydroxide (200 grams dissolved in 80 cubic centimeters of water and 800 cubic centimeters of aldehyde-free alcohol). The mixture was heated (reflux) on a water bath for about four hours, after which the excess alcohol was removed by distillation. The residual soaps were decomposed with dilute sulphuric acid (1: 3) and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resins were separated from the acid by filtering. The gasoline was then removed by distillation and the residue crystallized several times from alcohol (95 per cent). The melting point was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid with phosphorus trichloride. The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid was allowed to drop slowly into the substituted phenol.

CHAULMOOGRYL 2,4 DICHLOR PHENOL

$$\left.\begin{array}{l} CH = CH \\ | \\ CH_2 = CH_2 \end{array}\right\rangle CH(CH_2)_{12}COOC_6H_3Cl_2 \quad (2,4)$$

This compound was prepared by treating the acid chloride of chaulmoogric acid with 2,4 dichlor phenol in the presence of anhydrous zinc chloride. Twenty grams of chaulmoogric acid were placed in a flask which was then connected to a reflux condenser. The flask was warmed gently with a small flame until the acid melted, after which 2.3 cubic centimeters of phosphorus trichloride were added slowly from a dropping funnel placed in the top of the condenser. The mixture was then heated gently until the reaction was apparently finished, which required about fifteen minutes. Phosphorous acid separated at the bot-

[3] Philip. Journ. Sci. 33 (1927) 265.

tom and side of the flask, while the acid chloride remained as a light supernatant liquid. In order to eliminate the phosphorous acid and other impurities, the acid chloride was filtered through glass wool and the clear filtrate allowed to drop immediately into 8 grams of 2,4 dichlor phenol. The mixture was then treated gradually with 10 grams of anhydrous zinc chloride and heated (reflux) in a Crisco oil bath to a temperature of about 110° C. until the vapors of hydrochloric acid were completely eliminated, which required about a half hour. The reaction product, which was a black oily mass, was poured into water and washed several times by decantation to eliminate the zinc chloride. The mass was then extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, filtered, and the ether eliminated by distilling. The residue was then distilled in vacuo. The first fraction was a colored oil which distilled over at about 100° C. under 17 millimeters pressure. The second fraction was obtained at about 203° C. with 4 millimeters pressure. A small black residue remained in the flask. When cooled the second fraction solidified. This was then dissolved in hot methyl alcohol, the solution decolorized with animal charcoal, and allowed to crystallize. The melting point was 53.1 to 55.1° C. and the yield about 26 per cent. The ester was soluble in the common organic solvents.

Analysis:	Chlorine. Per cent.
Calculated for $C_{24}H_{34}O_2Cl_2$	16.68
Found	16.24

CHAULMOOGRYL 2,4 DIBROM PHENOL

$$\left.\begin{array}{l} CH=CH \\ \vert \\ CH_2-CH_2 \end{array}\right\rangle CH(CH_2)_{12}COOC_6H_3Br_2\ (2,4)$$

The acid chloride of chaulmoogric acid was prepared first by treating melted chaulmoogric acid (20 grams) with 2.3 cubic centimeters of phosphorus trichloride. The acid chloride, thus obtained, was filtered through glass wool and allowed to drop immediately into 17 grams of 2,4 dibrom phenol. The mixture was heated (reflux) in a Crisco oil bath to a temperature of 130° C. until the vapors of hydrochloric acid were completely eliminated. This required about five days. The reaction product, which was a brown mass, was dissolved in hot methyl alcohol, the solution decolorized with animal charcoal, and al-

lowed to crystallize. After crystallizing several more times from methyl alcohol, crystals were obtained which melted at 57.2 to 60.2° C. The yield was about 14 per cent. This ester was found to be soluble in the common organic solvents.

Analysis:	Bromine. Per cent.
Calculated for $C_{24}H_{34}O_2Br_2$	31.10
Found	30.84

The reaction of 2,4 dichlor phenol with the acid chloride of chaulmoogric acid in the presence of zinc chloride required only about a half hour for completion and gave a yield of about 26 per cent.

The reaction of 2,4 dibrom phenol with the acid chloride of chaulmoogric acid required about five days for completion and gave a yield of only about 14 per cent. Zinc chloride was used in making the chaulmoogryl 2,4 dichlor phenol and the yield obtained was about 26 per cent. As no zinc chloride was used in making the chaulmoogryl 2,4 dibrom phenol, these experiments would seem to indicate that zinc chloride is a very convenient condensing agent for the preparation of esters such as these.

HYDROQUINONE ESTER OF CHAULMOOGRIC ACID

$$\left[\begin{array}{l} CH = CH \\ \vert \\ CH_2 - CH_2 \end{array} \Big\rangle CH(CH_2)_{12}COO\right]_2(P)C_6H_4$$

This compound was prepared by treating the acid chloride of chaulmoogric acid with hydroquinone. Twenty grams of chaulmoogric acid were placed in a flask which was warmed with a small flame till the acid melted. The flask was then connected to a reflux condenser and 2.3 cubic centimeters of phosphorus trichloride were added slowly from a dropping funnel placed on the top of the condenser. After heating the mixture with a small flame for about fifteen minutes, the reaction was finished. Phosphorous acid separated at the bottom and side of the flask, while the acid chloride remained as a light supernatant liquid. In order to eliminate the phosphorous acid and other impurities, the acid chloride was filtered through glass wool and the clear filtrate allowed to drop immediately into 4 grams of hydroquinone. The mixture was heated (reflux) in a Crisco oil bath to a temperature of about 120° C. until the

vapors of hydrochloric acid were completely eliminated. After heating the mixture for about four days, the reaction was practically complete. When cooled, the reaction product was a hard brown mass. A small quantity of the hydroquinone sublimed near the top of the flask. The solid, brown, reaction product was dissolved in absolute alcohol, the solution treated with bone black to decolorize it, filtered, and the filtrate allowed to crystallize. The product was crystallized several more times from methyl alcohol using animal charcoal to decolorize the solution. The white crystals thus obtained gave a melting point of 54.1 to 57.2° C., and the yield was about 18 per cent. The ester was soluble in the common organic solvents.

Analysis:	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{42}H_{66}O_4$	79.49	10.41
Found	79.14	9.79

CHAULMOOGRYL M-HYDROXY ETHYL BENZOATE

$$\begin{array}{l} CH = CH \\ CH_2 - CH_2 \end{array} \Big\rangle CH(CH_2)_{12}COO\text{-}M\text{-}C_6H_4COOC_2H_5$$

The acid chloride of chaulmoogric acid, prepared from 20 grams of chaulmoogric acid and 2.3 cubic centimeters of phosphorus trichloride, was filtered through glass wool and allowed to drop into 11.5 grams of the ethyl ester of *m*-hydroxy benzoic acid. The mixture was treated gradually with 10 grams of anhydrous zinc chloride and heated (reflux) in a Crisco oil bath to a temperature of about 120° C. until the vapors of hydrochloric acid were completely eliminated which required about a day. The black oily reaction product was washed by decantation several times with water, after which the product was extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, filtered, and the ether eliminated by distilling. The residue was then distilled in vacuo. The first fraction, which passed over at about 100° C. (16 millimeters), was a colorless oil. The second fraction passed over at about 160° C. (12 millimeters) and when cooled became a white solid. A black residue remained in the flask. The white solid (second fraction) was dissolved in methyl alcohol and the solution decolorized with animal charcoal. When crystallized, white crystals were obtained which melted at 56.1 to 59.2° C. The ester was soluble in the common organic solvents.

Analysis:	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{27}H_{40}O_4$	75.70	9.35
Found	75.65	9.64

SUMMARY

Four new esters of chaulmoogric acid were prepared in this investigation. They were chaulmoogryl 2,4 dichlor phenol, chaulmoogryl 2,4 dibrom phenol, hydroquinone ester of chaulmoogric acid, and chaulmoogryl *m*-hydroxy ethyl benzoate. These esters are soluble in the common organic solvents.

AN AID IN BENDING GLASS TUBING IN THE LABORATORY

By Ray N. Allen

Chemist, Bureau of Science, Manila

ONE PLATE

There is always the difficulty in forming short bends in glass tubing of preventing collapse of the tube wall. When the wall is extra thin or thick with relation to the size of the bore, the difficulty increases markedly. A skilled glass worker can make such bends by careful blowing, but for the average laboratory man this is a tedious process, though not actually beyond his ability.

An easy rapid method of making otherwise difficult bends is to tamp dry asbestos fiber, such as is used for filters, tightly in the bore of the tube where the desired bend is to be made. The glass can then be heated and bent without regard to collapsing since the viscous glass is supported by the asbestos core. After cooling, the asbestos can be picked out with a piece of wire, as it does not fuse into the glass.

No investigation of the literature was made to determine the novelty of this idea, but it is hoped that it will at least be new to some chemists.

ILLUSTRATION

PLATE 1. A piece of bent glass tubing, packed with asbestos fiber to prevent collapse during the bending. 301

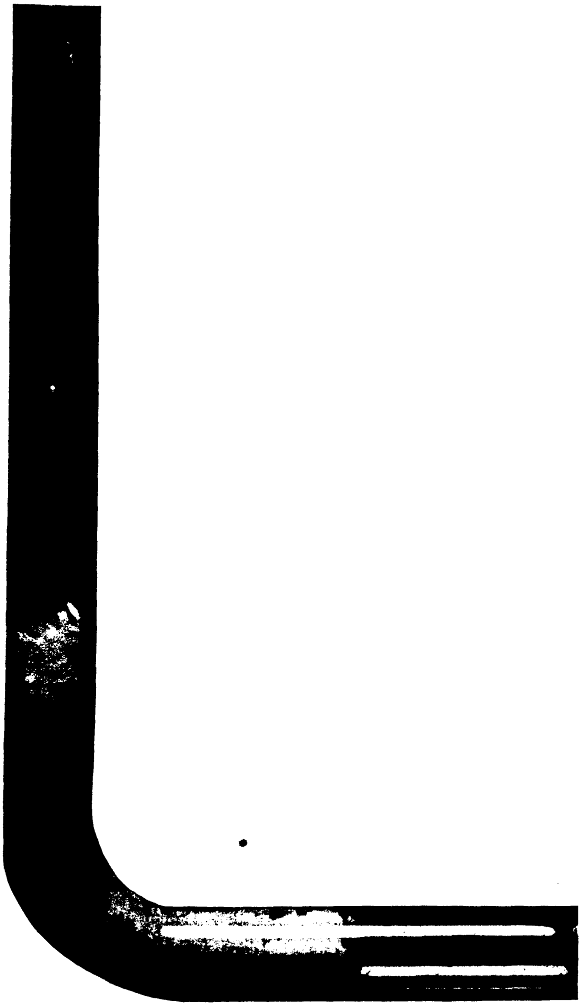

PLATE 1.

FAUNA PHILIPPINICA, SCYDMAENIDÆ, COLEOPTERA

By CTIBOR BLATTNÝ

Doctor of Engineering, Prague, Czechoslovakia

TWO PLATES

The late explorer Charles Fuller Baker had brought together an excellent and comparatively large collection of Scydmaenidæ from the northern Philippines, which he conveyed to me for determination. It contained sixty-four specimens representing twelve species. The genus *Cephennodes* is represented by two species, *Napochus* by one, *Euconnus* by one, and *Scydmaenus* by eight. The manifold differentiation of the Scyrmaenidæ as to countries becomes visible here again; according to the author's view the Philippines do not include any species known from Asia or from the Indomalayan islands. The relations to the continent and to the islands of the Far East (for example, Japan and Formosa) are more evident than to Java, Sumatra, etc. Some of the Scydmaenidæ are probably local varieties. It has been found impossible to group the species of *Scydmaenus* and *Euconnus* to form natural unities. I will try to determine their systematic positions after having treated the species from other countries, of which I have material at hand from Siberia, Burma, and Ussuri, and from Sumatra and other islands.

The types of the species described in this paper have been deposited in the United States National Museum, Washington, and the cotypes in the National Museum in Prague, Czechoslovakia.

CEPHENNODES LUZONICUS sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 2 ex.

Obscure brunneo-testaceus, nitidus, densius cospicue punctulatus, sat longe, luteo-brunnee pubescens, sternum et venter piceo-brunnea, pygidium luteo-testaceum, pedes et antennae rubro-testacei. Capite brevi, oculis magnis, ex nonnulis grossis facettis compositis, nigris, fere totam capitis marginem lateralem occludentibus. Palpis grandibus, luteis, articulo praeultimo longe ovate-conico, apice abscisso, ultimo tuberculiformi. Antennis robustis, breviter dense pubescentibus, fere 0.2 ely-

trarum longitudinis attingentibus, articulo 1 et 2 recteliniis, 3 ad 6 globulosis, minimis, nitidis, 7 ad 11 maioribus, 7 ad 10 arcuatis, clava 3-articulata, articulis 9 et 10 haud transversis, 11 ovate fere regulariter conico, extus magis attenuato, apice acuminato, basi rotundata, articulis 7 ad 11 dupliciter pubescentibus, haud nitidis, luteius. Prothorace in $\frac{2}{3}$ a basi latissimo, hic rotundato anticem magis quam posticem, fere rectelinie, posticem minus, sed sat, parum emerginate attenuato, anticem medio maxime convexo, inde ad latera deplanato; dimidio posteriore planiore, marginibus posticem carinatis et crenulatis, ante angulos posticos utrinque fovea rotunda magna haud profunda. Elytris convexis, in $\frac{1}{3}$ a basi latissimis, parum a basi fere rectelinie dilatatis, posticem praecipue attenuatis; fovea basali grande, profunda, transversim elliptice-rotundata, ad suturam aequaliter quasi ad humerum approximata; stria humerali magna, ad basin dilatata, deplanata, intrahumerali stria profunda, obliqua, basi in forma foveae minimae dilatata, posticem parum arcuata, anticem basi foveam basalem extus attingente, posticem 0.5 elytrarum longitudinis attingente. Humeris glabris, parum elatis. Pygidio brevi. Carina mesosternali longa, acuta, glabra, carina metasternali triangularem, medio profundisimam impressionem in angulo 60° occludente, metasterno medio marginis postecae 3-angulariter exsculpto. Metasterno medio glabro, lateribus nec profunde implanatis et hic longe lutee pubescentibus. Segmento vetrali ultimo medio deplanato, segmentis ventralibus punctulatis, breviter pubescentibus. Pedibus longis, tenuibus, femoribus parum clavate incrassatis, tibiis longis, simplicibus, in forma digiti incrassatis, in dimidio apicali densius pubescentibus, tarsis longis, gracilibus, apud ♂ et ♀ simplicibus (Tab. 1, fig. 1).

Dimensiones

	mm.
Capitis:	
Longitudo	0.13
Latitudo maxima	0.36
Prothoracis:	
Longitudo	0.31
Latitudo maxima	0.54
Latitudo antice	0.41
Latitudo basi	0.49
Longitudo oculorum	0.08
Elytrarum:	
Latitudo basi	0.49
Latitudo maxima	0.58–0.63
Longitudo (cum pygidio)	0.83

Dimensiones—Continued.

Articuli palporum praeultimi:		mm.
Longitudo		0.08
Latitudo		0.04
Articuli palporum ultimi:		
Longitudo		0.01
Latitudo		0.01
Longitudo corporis		1.29
Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.05	0.06
II.	0.04	0.04
III.	0.03	0.02
IV.	0.03	0.02
V.	0.03	0.02
VI.	0.03	0.02
VII.	0.04	0.04
VIII.	0.06	0.04
IX.	0.07	0.08
X.	0.11	0.09
XI.	0.16	0.09
Longitudo antennarum	0.68	

Differt ab omnibus adhuc descriptis speciebus huius generis.

The genus *Cephennodes* is the Pacific representative of the European genus *Cephennium*, inhabiting the islands and the continent from Siberia to India and probably divided into a series of species, differentiated by small, but nevertheless, important characters.

CEPHENNODES BAKERI sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 1 ex.

Praecaedenti similis, minor, dimensiones aliae, obscurior, longius et rarius pubescens, punctulatus, articuli antennarum alii, 11 brevior, oculi minores, elytrarum margines minus arcuatae, fovea angulorum posticorum prothoracis profunda, grossa, stria interhumerali elytrarum paulo breviore, pedes graciliores, metasterum vix 3-angulariter impressum, angulus carinae mesosternalis 50° (Tab. 1, fig. 2).

Dimensiones

Capitis:	mm.
Longitudo	0.09
Latitudo	0.33
Prothoracis:	
Longitudo	0.33
Latitudo maxima	0.46
Latitudo antice	0.36
Latitudo basi	0.43
Longitudo oculorum	0.05

Dimensiones—Continued.

	Long. mm.	Lat. mm.
Elytrarum:		mm.
Latitudo basi		0.49
Latitudo maxima		0.53
Longitudo		0.58
Articuli praeultimi palporum:		
Longitudo		0.06
Latitudo		0.04
Articuli ultimi palporum:		
Longitudo minus quam		0.01
Latitudo mnus quam		0.01
Longitudo corporis		0.99
Antennarum articuli:		
I.	0.06	0.05
II.	0.05	0.03
III.	0.03	0.03
IV.	0.03	0.03
V.	0.03	0.03
VI.	0.03	0.03
VII.	0.03	0.03
VIII.	0.03	0.04
IX.	0.05	0.07
X.	0.06	0.08
XI.	0.09	0.08
Longitudo antennarum	0.49	

The intimate relationship with the preceding species proves the homogenity of this insular group of the genus *Cephennodes* as well as of a considerable number of species unknown up to now.

NAPOCHUS BAKERI sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 1 ex.

Clare castaneo-brunneus, nitidus, caput longe, rare, praecipue barbate temporibus pubescens, prothorax densissime longissime, lateribus fere crispe pubescens, elytrae longe luteo-auree pubescentes. Rarissime elytris punctulatus, dense microscopiter prothorace. Capite posticem valde attenuato, temporibus longis, parum arcuatis, oculis mediocribus, antice sitis, grosse facettatis, palpis normalibus. Antennis sat gracilibus, basin prothoracis haud attingentibus, articulis 1 et 2 fere cylindro-subconicis, 3 ad 5 magis, 6 et 7 minus arcuatis, 8 ad 11 clavam validam formantibus, transversis et attenuatis, 11 ovate-conico, apicem attenuato, obtusato. Antennis nitidis, longe et dense pubescentibus. Prothorace conico, anticem a basi valde attenuato, antice lateribus parum intus sinuatis, ante basin stria transversa profunda, lateribus et medio obsolete in fovea elliptica transversim dilatata. Prothorace medio tota fere longitudine glabro, nec pu-

bescente. Elytris arcuatis, valde dilatatis et attenuatis, in triente apicali latissimis, dente humerali valida, obtusata, stria humerali profunda, longa, elytrarum basi utrinque impressione minima, stria suturali integra, elytris parum, ad suturam magis deplanatis. Pedibus mediocribus, luteo-testaceis, apice femorum obscuriore, femoribus parum incrassatis, tibiis sat incrassatis et incurvatis, tarsis mediocribus, trochanteris securiformibus, sat longis. Metasterno et prosterno castaneo-piceis, nitidis, glabris, metasterno convexo, segmentis ventralibus castaneis, dense brevissime luteo-auree pubescentibus, simplicibus ♀ (Tab. 1, fig. 3).

Dimensiones

		mm.
Capitis:		
Longitudo		0.22
Latitudo maxima		0.33
Prothoracis:		
Longitudo		0.36
Latitudo maxima		0.52
Latitudo antice		0.19
Longitudo oculorum		0.08
Elytrarum:		
Latitudo basi		0.56
Latitudo maxima		0.69
Longitudo		0.91
Longitudo corporis		1.49

Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.05	0.05
II.	0.06	0.05
III.	0.02	0.02
IV.	0.02	0.02
V.	0.03	0.02
VI.	0.03	0.02
VII.	0.03	0.02
VIII.	0.04	0.06
IX.	0.04	0.06
X.	0.04	0.07
XI.	0.06	0.07
Longitudo antennarum (cum basibus clavae)	0.48	

Ad Schenklingi Reitter ex Formosa, maior, punctulatus, differt structura prothoracis, capite, antennis tec. Sine dubio vicarians.

EUCONNUS BAKERIANUS sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 38 ex. (16 ♂♂, 22 ♀♀).

Clare castaneo-ruber, nitidus, capite et elytris glabris, nitidissimis, elytris rarissime microscopiter, vix conspicue punctu-

latis, nonnulis brevissimis setis, prothorace dense, crispe longe lutee pubescente. Capite convexo, structura nulla, ad basin sat, arcuate attenuato, margine antica arcuata, oculis minutis, apud ♀ minoribus. Articulo palporum praeultimo longe clavate-ovate, intus parum insinuato, ultimo brevi, tenuissimo, palpis breviter pubescentibus. Antennis longe aureo-lutee pubescentibus, art. 1 fere cylindrico, 2 parum subconico, sequentibus lateribus parum convexis, clava sat crassa, 4-articulata, articulo ultimo ovate-acuminato, intus parum insinuato. Apud ♂ art. 7, 8, et 9 intus inferius medio tuberculiforme dilatatis. Antennis 0.2 elytrarum longitudinis attingentibus. Prothorace parum conico, convexo, lateribus arcuatis, structura nulla. Elytris late ovatis, basi lata, lateribus regulariter arcuatis, pygidio haud conspicuo. Elytris convexis, humeris haud elatis, basi duabus brevibus vix conspicuis impressionibus, stria humerali apud ♂ conspicua, brevissima, obsoleta, diffusa. Elytris apice separate rotundatis. Corpore inferius dense brevissime pubescente, metasterno convexo, trochanteris posticis brevibus, late plane clavatis, margine metasterni postica inter coxas posteriores plane excissa. Pedibus dense breviter pubescentibus.

♂. Femoribus anticis maxime clavatis, superius in $\frac{1}{3}$ apicali fovea magna rotundo-elliptica, tibiis anticis, mediis et posticis incrassatis, incurvatis, dimidio apicali intus sinuatis, densissime inde pubescentibus, tibiis posticis rectis. Femoribus posticis et mediis basi tenuibus, apice clavate incrassatis. Trochanteris posticis longioribus, tarsis longis et crassis.

♀. Femoribus normaliter incrassatis, tibiis minus quam apud ♂ incurvatis, tarsis simplicibus (Tab. 1, fig. 4, ♂).

Dimensiones ♂

	mm.
Capitis:	
Longitudo	0.31
Latitudo maxima	0.39
Prothoracis:	
Longitudo	0.49
Latitudo maxima	0.41
Latitudo basi	0.29
Elytrarum:	
Longitudo	0.91
Latitudo maxima	0.77
Longitudo oculorum	0.04
Articuli palporum praeultimi:	
Longitudo	0.11
Latitudo	0.03

Dimensiones ♂—Continued.

Articuli palporum ultimi:		mm.
Longitudo		0.01
Latitudo minus quam		0.01
Longitudo corporis		1.71
Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.08	0.06
II.	0.06	0.05
III.	0.06	0.04
IV.	0.06	0.04
V.	0.06	0.04
VI.	0.06	0.04
VII.	0.06	0.04
VIII.	0.08	0.06
IX.	0.08	0.08
X.	0.09	0.08
XI.	0.14	0.08
Longitudo antennarum	0.83	

Euconno laevissimo Motschulsky ex Birma proximus, differt structura pedum, antennis, etc.

The sizes vary slightly; the aforesaid points are important for the relation between the various sizes.

SCYDMAENUS BAKERIANUS sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 1 ex.

Luteo-rubrescens, angustus, convexus, nitidus, capite et prothorace vix punctatis, brevissime pubescens, elytris densius conspicue punctulatis, aureo-lutee pubescentibus. Capite posticem vix attenuato, medio antice rotunde-elliptice deplanato, hic dense punctato, a medio marginis posticae anticem in 0.75 longitudinis capitis a basi utrinque stria divergente, sat profunda. Oculis minutis. Angulis posticis obtuse angulatis. Antennis gracilibus, tenuibus, basin elytrarum superantibus, art. 1 fere cylindrico, 2 ad 7 parum subconicis, lateribus fere rectis, 8 intus attenuato, clava 3-articulata, parum distincta, art. 9 octavo maiore, 9 et 10 fere subconicis, 11 conice-ovato, obtuse acuminato. Antennis breviter dense pubescentibus. Palporum articulo praeultimo longe ovato, ultimo rudimentario, brevissimo, obtuso. Prothorace fere ovate-cordato, posticem parum emarginato, convexo, basi stria obsoleta, utrinque in forma transversae foveae dilatata, foveis aequaliter inter se quasi a margine distantibus, haud profundis, basi punctulata. Elytris ovatis, sat arcuate dilatatis, magis posticem attenuatis, apice obtuse

rotundatis, pygidio brevi, conspicuo, luteo, humeris vix conspicuis, impressione basali haud profunda, dorso-humerali, sutura ad apicem parum depressa. Pedibus longis, tenuibus, femoribus anticis et mediis clavatis, posticis minus clavate incrassatis, tibiis in forma digiti, anticis magis dilatatis, extus apice breviter spinulatis, tibiis posticis longissimis, intus angulate, sed parum dimidio apicali dilatatis, tarsis (♂) longis, gracilibus, anticis in primis articulis dilatatis, trochanteris posticis clavatis, longissimis, angustis. Metasterno glabro, medio marginis posticae late, fere demirotunde obsolete impresso, margine postica recta. Sternitis ventralibus brevibus, graciliter pubescentibus, sternito ultimo magno, semirotunde-rhomboidali, luteo (Tab. 1, fig. 5).

Dimensiones

	mm.
Capitis:	
Longitudo	0.29
Latitudo	0.36
Prothoracis:	
Longitudo	0.52
Latitudo basi	0.29
Latitudo maxima	0.46
Latitudo antice	0.24
Longitudo oculorum	0.05
Elytrarum:	
Latitudo basi	0.46
Latitudo maxima	0.66
Longitudo (cum pygidio)	1.08
Longitudo pygidii	0.13
Articuli palporum praeultimi:	
Longitudo	0.11
Latitudo	0.04
Articuli palporum ultimi:	
Longitudo	0.01
Latitudo	0.01
Longitudo corporis	1.89

Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.08	0.04
II.	0.06	0.03
III.	0.06	0.03
IV.	0.08	0.03
V.	0.08	0.03
VI.	0.09	0.03
VII.	0.06	0.03
VIII.	0.06	0.04
IX.	0.08	0.05
X.	0.08	0.06
XI.	0.13	0.08
Longitudo antennarum	0.86	

This species differs by its head structure from all known species; according to the old classification it would belong to the subgenus *Cholerus* C. G. Thomson, but it has also numerous characters of the subgenus *Eustemnus* Reitter. In accordance with the new classification the new species has the conspicuous characters of the Indomalayan *Scydmaenus;* namely, the stricture of article 8 of the antennæ. The long fine legs and the extremely long trochanters of all the legs characterize a group of this genus that is confined to the Philippines.

SCYDMAENUS BAKERI sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 1 ex.

Clare-castaneo-ruber, nitidus, sat dense punctatus, capite et prothorace brevius, elytris longius aureo-lutee, sat adhaese pubescentibus. Capite posticem parum, arcuate attenuato, oculis minutis, angulis posticis obtuso-rotundatis, vertice medio glabro, fronte leviter declivi et densius punctata. Articulo palporum praeultimo brevius ovato. Antennis similiter formatis, articulis 2 ad 6 subconicis, 7 intus insinuato, 8 irregulariter quadratico, 9 et 10 parallelis, 11 longo, conico. Prothorace fere cylindrico, posticem et anticem arcuate rotundato, marginibus postice crenulatis, basi stria tenuissima, ceterum sine structura. Elytris longe regulariter ovatis, parum arcuatis, humeris humilibus, brevibus, impressione basali obsoleta. Elytrarum apice quasi apud praecaedentem, sutura haud impressa. Pedibus longis, tenuibus, trochanteris posticis longissimis, breviter acuminatis. Metasterno (et sternitis ventralibus) rare pubescente, convexo, similiter quam apud praecaedentem formato, coxis posticis sat distantibus, tarsis tenuibus, simplicibus ♀ (Tab. 1, fig. 6).

Dimensiones

	mm.
Capitis:	
Longitudo	0.29
Latitudo maxima	0.33
Latitudo basi	0.28
Prothoracis:	
Longitudo	0.49
Latitudo maxima	0.44
Latitudo basi	0.39
Latitudo antice	0.33
Elytrarum:	
Longitudo (cum pygidio)	1.16
Latitudo basi	0.49
Latitudo maxima	0.66
Longitudo pygidii	0.16

Dimensiones—Continued.

Articuli palporum praeultimi:		mm.
Longitudo		0.14
Latitudo		0.05
Articuli palporum ultimi:		
Longitudo minus quam		0.01
Latitudo minus quam		0.01
Longitudo corporis		1.94
Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.08	0.04
II.	0.06	0.04
III.	0.06	0.03
IV.	0.06	0.03
V.	0.06	0.03
VI.	0.08	0.04
VII.	0.08	0.04
VIII.	0.08	0.07
IX.	0.09	0.07
X.	0.09	0.07
XI.	0.19	0.08
Longitudo antennarum	0.92	

The lack of shield structure and elytra indicate that this species belongs to the old subgenus *Cholerus*. The species is remarkable for the long trochanters and the formation of the articles of the antennæ, which are characteristic of Philippine species.

SCYDMAENUS BANAHAO sp. nov.

LUZON, Mount Banahao; Baker leg., 1 ex.

Castaneo-ruber, capite et prothorace nitidis, glabris, rare breviter pubescentibus, elytris dense rugose punctatis, opacis, dense adhaese pubescentibus. Capite posticem parum attenuato, angulis posticis obtusate rotundatis, oculis sat grandibus, palporum articulo praeultimo longe clavate-ovato, antennis prothoracis basin haud attingentibus, validis, art. 1 ad 4 lateribus fere rectis, obconicis, 5 ad 8 brevibus, lateribus arcuatis, 6, 7, et 8 intus attenuatis, 9, 10, et 11 clavam validam formantibus, 9 et 10 lateribus arcuatis, 11 breviter conice ovato, obtusato, antennis dense breviter pubescentibus. Prothorace posticem parum, fere rectelinie, anticem magis, rotundate attenuato, in $\frac{2}{3}$ a basi latissimo, basi ante striolam basalem utrinque foveis duabus transversim ellipticis, internis earum valde inter se distantibus. Elytris longe ellipticis, parum et paulum arcuate dilatatis, parum posticem attenuatis, apice abscisso, basi impressione suturo-humerali transversa, haud profunda, lata, humeris brevibus, humilibus, obtusis. Pedibus longis, validis, bre-

viter dense pubescentibus, femoribus clavate incrassatis, tibiis angulariter plane dilatatis, mediis dimidio apicali longius pubescentibus, apice extus et intus breviter spinosis, tarsis robustis, articulis tarsorum anticorum basalibus paulum dilatatis, trochanteris posterioribus longe clavatis. Metasterno convexo, dense breviter pubescente, glabro, sternitis ventralibus glabris, pubescentibus, ultimo rotundato ♂ (Tab. 1, fig. 7).

Dimensiones

Capitis:		mm.
Longitudo		0.29
Latitudo maxima		0.46
Latitudo basi		0.39
Prothoracis:		
Longitudo		0.56
Latitudo maxima		0.49
Latitudo basi		0.32
Latitudo antice		0.29
Elytrarum:		
Longitudo (cum pygidio)		1.17
Latitudo basi		0.46
Latitudo maxima		0.74
Longitudo pygidii		0.10
Longitudo oculorum		0.11
Articuli palporum praeultimi:		
Longitudo		0.19
Latitudo		0.06
Articuli palporum ultimi:		
Longitudo minus quam		0.01
Latitudo minus quam		0.01
Longitudo corporis		2.02
Articuli antennarum:	Long. mm.	Lat. mm.
I.	0.09	0.04
II.	0.04	0.03
III.	0.04	0.03
IV.	0.04	0.03
V.	0.04	0.04
VI.	0.04	0.04
VII.	0.06	0.04
VIII.	0.06	0.04
IX.	0.08	0.08
X.	0.09	0.09
XI.	0.14	0.09
Longitudo antennarum	0.72	

This species, remarkable for the long legs and trochanters (Philippine) and the attenuation of the articles of the antennæ (Indomalayan), may belong, because of its shield and elytron structure, in the old subgenus *Scydmaenus* s. str.

SCYDMAENUS TANGCOLAN sp. nov.

MINDANAO, Bukidnon, Tangcolan; Baker leg., 3 ex. (1 ♀, 2 ♂ ♂).

Castaneus, densissime tenuiter punctulatus, praecipue elytris, capite rarius, prothorace dense semiadhaese, elytris densissime adhaese luteo-grisee pubescentibus, capite et prothorace sat nitidis, elytris haud nitidis. Capite posticem parum attenuato, oculis sat minutis, angulis posticis obtuse rotundatis, fronte medio deplanata et anticem declivi, palporum articulo praeultimo longe clavate-ovato, antennis robustis, basin prothoracis attingentibus, art. 1 cylindrico, 2 obconico, 3 extus insinuato, 4 intus sinuato, sequentibus lateribus parum arcuatis, 8 intus attenuato, clava distincta, 3-articulata, art. 9 et 10 arcuato-subconicis, 11 breviter ovato, apice obtusato. Prothorace posticem valde, parum emarginate, anticem valde, magis arcuate attenuato, in $\frac{3}{4}$ longitudinis a basi latissimo, hic rotundato, basi ante striam transversalem fere inconspicuam foveis mediocribus rotundis haud profundis quattuor, internis earum inter se magis distantibus, basi ipsa utrinque plane impressa. Elytris breviter ellipticis, valde, parum arcuate dilatatis, posticem magis arcuate attenuatis, impressione basali obsoleta, humeris distinctis, humilibus, obtusatis, apice elytrarum rotundato, pygidio brevissimo. Pedibus robustis, trochanteris posticis breviter clavatis, apice acuminatis, tibiis, praecipue anticis, validis, anticis in triente apicali crenulatis-dentatis, intus sinuatis, femoribus clavate incrassatis, tarsis robustis, apud ♂ dilatatis. Pedibus castaneis, breviter dense pubescentibus. Metasterno ♂ medio ad coxas posticas deplanato, postice recte abscisso, sternito ultimo haud profunde demirotunde impresso, metasterno rare tenuiter punctulato et pubescente, sternitis dense punctulatis et pubescentibus, ultimo luteo, ♀ metasterno convexo, sternitis simplicibus (Tab. 1, fig. 8).

Dimensiones ♂

	mm.
Capitis:	
Longitudo	0.36
Latitudo maxima	0.48
Latitudo basi	0.39
Prothoracis:	
Longitudo	0.52
Latitudo maxima	0.58
Latitudo basi	0.38
Latitudo antice	0.39

Dimensiones ♂—Continued.

Elytrarum:		mm.
Longitudo (sine pygidio)		1.22
Latitudo basi		0.49
Latitudo maxima		0.83
Longitudo pygidii		0.10
Longitudo oculorum		0.10
Articuli palporum praeultimi:		
Longitudo		0.19
Latitudo		0.07
Articuli palporum ultimi:		
Longitudo minus quam		0.01
Latitudo minus quam		0.01
Longitudo corporis		2.20
Articuli antennarum:	Long. mm.	Lat. mm.
I.	0.14	0.06
II.	0.07	0.03
III.	0.07	0.03
IV.	0.07	0.03
V.	0.07	0.04
VI.	0.06	0.04
VII.	0.04	0.04
VIII.	0.04	0.05
IX.	0.09	0.08
X.	0.11	0.09
XI.	0.14	0.09
Longitudo antennarum	0.90	

Dimensiones ♀ similiter, minores, ad ex.: Longitudo corporis, 2.12 mm.; latitudo elytrarum, 0.81 mm.; etc.

This and the following two species differ from the other Philippines species in the formation of the trochanters and come nearer to the species of the Indomalayan islands and of the continent, with which they have in common the attenuation of the articles of the antennæ. This and the following species are probably to be counted among varieties.

SCYDMAENUS SIBUYANI sp. nov.

Sibuyan Island; Baker leg., 1 ex.

Praecaedenti similis. Castaneo-piceus, pedibus castaneis, parum nitidior, tenuiter punctulatus, paulo rarius, longius, lutee pubescens. Palporum articulo praeultimo brevius clavate incrassato. Oculis ex parvis facettis compositis angulis capitis posticis magis attenuatis, rotundatis, prothorace longiore, minus anticem et posticem attenuato, basi quattuor grandibus foveis profundis, earum internis maxime inter se distantibus, angulis posticis parum constrictis et crenulatis. Elytris minus, sed ma-

gis arcuate dilatatis, humeris validis, obtusatis, impressione basali bene distincta, in ea fovea humerali fere rotunda, sutura basi parum elevata. Pedibus longioribus, paulo gracilioribus, tibiis apice breviter spinulatis. Metasterno convexo, ad coxas posticas deplanato et quasi sterniti dense punctulato et breviter pubescente, sternito ultimo simplice, brunneo-castaneo ♂ (Tab. 1, fig. 10).

Dimensiones

Capitis:		mm.
Longitudo		0.33
Latitudo maxima		0.38
Latitudo basi		0.33
Prothoracis:		
Longitudo		0.62
Latitudo maxima		0.56
Latitudo basi		0.41
Latitudo antice		0.33
Elytrarum:		
Longitudo (sine pygidio)		1.21
Latitudo basi		0.58
Latitudo maxima		0.89
Longitudo pygidii		0.16
Longitudo oculorum		0.09
Articuli palporum praeultimi:		
Longitudo		0.16
Latitudo		0.06
Articuli palporum ultimi:		
Longitudo		0.01
Latitudo		0.02
Longitudo corporis		2.32
Antennarum articuli:	Long. mm.	Lat. mm.
I.	0.11	0.04
II.	0.06	0.04
III.	0.06	0.04
IV.	0.06	0.04
V.	0.06	0.05
VI.	0.06	0.06
VII.	0.06	0.07
VIII.	0.06	0.07
IX.	0.08	0.09
X.	0.09	0.10
XI.	0.19	0.10
Longitudo antennarum	0.89	

SCYDMAENUS MAQUILINGENSIS sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 3 ex. (2 ♂ ♂, 1 ♀).

Clare castaneo-ruber, nitidus, fere glaber, capite et prothorace breviter dense semiadhaese, elytris longius dense lutee pubescentibus. Capite posticem attenuato, angulis posticis obtuse rotundatis, oculis minutis, palporum articulo praeultimo clavate-ovato, atennis nitidis, breviter dense pubescentibus, basin prothoracis haud attingentibus, articulis 1 et 2 cylindro-subconicis, sequentibus lateribus arcuatis, clava 3-articulata, valida, art. 9 et 10 arcuatis, 11 breviter ovate acuminato, lateribus apicem parum intus sinuatis. Prothorace posticem fere rectelinie, magis anticem attenuato, loco latissimo in $\frac{2}{3}$ a basi sito rotundato, basi foveis quattuor, profundis, internis earum inter se maxime distantibus. Elytris longe ovatis, fere rectelinie dilatatis, magis posticem, arcuate attenuatis, humeris validis, obtusatis, impressione basali bene conspicua, sat longa et profunda, sutura basi utrinque elevata. Apice elytrarum separate rotundato. Pygidio brevi. Pedibus luteo-rubris, mediocribus, tibiis parum incrassatis, trochanteris posticis clavatis, tarsis anterioribus et mediis apud ♂ vix conspicue dilatatis. Metasterno ♂ medio late longitudine tota 3-angulariter deplanato-impresso, impressione lateribus arcuatis, ♀ deplanato, sternitis simplicibus, metasterno et sternitis punctulatis, dense brevissime luteo-brunnee pubescentibus (Tab. 1, fig. 9).

Dimensiones

	mm.
Capitis:	
Longitudo	0.28
Latitudo maxima	0.38
Latitudo basi	0.25
Prothoracis:	
Longitudo	0.61
Latitudo maxima	0.49
Latitudo antice	0.39
Elytrarum:	
Longitudo (sine pygidio)	0.94
Latitudo basi	0.38
Latitudo maxima	0.76
Longitudo pygidii	0.11
Longitudo oculorum	0.09
Articuli palporum praeultimi:	
Longitudo	0.18
Latitudo	0.06
Articuli palporum ultimi:	
Longitudo minus quam	0.01
Latitudo	0.01
Longitudo corporis	1.94

Dimensiones—Continued.

Articuli antennarum:	Long. mm.	Lat. mm.
I.	0.13	0.04
II.	0.06	0.04
III.	0.05	0.04
IV.	0.05	0.04
V.	0.05	0.05
VI.	0.05	0.05
VII.	0.05	0.06
VIII.	0.05	0.06
IX.	0.06	0.08
X.	0.09	0.10
XI.	0.16	0.11
Longitudo antennarum	0.80	

Under the old classification this species would belong to the subgenus *Scydmaenus.*

SCYDMAENUS PHILIPPINICUS sp. nov.

LUZON, Mount Banahao; Baker leg., 3 ex.

Castaneo-ruber, paulo minus nitidus quam praecaedens, dense punctulatus, dense, elytris longius griseo-lutee pubescens. Capite vix posticem attenuato, angulis posticis rotundatis, vertice medio sat late et profunde impresso. Palporum articulo praeultimo ovato, antennis robutis, basin prothoracis haud attingentibus, art. 3 ad 8 obconicis, nitidis, rare pubescentibus, clava 3-articulata, valida, opaca, dense breviter pubescente, art. 9 et 10 lateribus parum arcuatis, 11 breviter ovate-conico, acuminato. Prothorace parum, emarginate posticem, valde anticem rotundate attenuato, basi medio stria minuta longitudinali, basin ipsam haud, 0.25 (et minus) longitudinis prothoracis a basi attingente, ante basin foveis quattuor magnis profundis, mediis earum inter se distantibus. Elytris parum arcuate dilatatis, ovatis, impressione basali distincta, nec profunda, in ea fovea dorsali et humerali perspicua, humeris obtusatis, sutura basi utrinque elevata. Pedibus mediocribus, trochanteris posticis longe clavatis, tibiis incrassatis, pubescentibus, mediis et anticis apice extus acuminatis, tarsis vix dilatatis, metasterno convexo, medio ad coxas posticas 3-angulariter deplanato, sat dense punctulato et pubescente, sternitis simplicibus, punctulatis et pubescentibus (Tab. 1, fig. 11).

Dimensiones

Capitis:	mm.
Longitudo	0.33
Latitudo maxima	0.46
Latitudo basi	0.33

Dimensiones—Continued.

	Long. mm.	Lat. mm.
Prothoracis:		mm.
Longitudo		0.62
Latitudo maxima		0.54
Latitudo basi		0.41
Latitudo antice		0.28
Elytrarum:		
Longitudo (sine pygidio)		1.15
Latitudo basi		0.49
Latitudo maxima		0.89
Longitudo pygidii		0.09
Longitudo oculorum		0.08
Articuli palporum praeultimi:		
Longitudo		0.19
Latitudo		0.06
Articuli palporum ultimi:		
Longitudo minus quam		0.01
Latitudo minus quam		0.01
Longitudo corporis		2.19
Articuli antennarum:	Long. mm.	Lat. mm.
I.	0.13	0.05
II.	0.08	0.04
III.	0.06	0.03
IV.	0.05	0.03
V.	0.05	0.03
VI.	0.05	0.04
VII.	0.05	0.04
VIII.	0.05	0.06
IX.	0.09	0.10
X.	0.09	0.12
XI.	0.18	0.13
Longitudo antennarum	0.88	

The systematic position of this species is uncertain, although some of its characters (structure of head and thorax) suggest the old group *Scydmaenus* s. str. Other characters are different.

SCYDMAENUS LUZONICUS sp. nov.

LUZON, Laguna, Mount Maquiling; Baker leg., 15 ex. (♂♂ et ♀♀).

Clare castaneo-ruber, nitidus, basi prothoracis et elytris paulo obscurioribus, capite et prothorace fere glabris, sat longe rare crispe pubescentibus, elytris rare et grosse punctatis, longe rare luteo-grisee pubescentibus. Capite posticem attenuato, angulis posticis obtuse rotundatis, oculis minutis, articulo palporum praeultimo longe clavate-ovato, antennis basin prothoracis superantibus, art. 1 ad 5 fere cylindricis, 2 ad 5 parum lateribus arcuatis, 6, 7, et 8 lateribus valde arcuatis, clava 3-articulata, 9

et 10 parum arcuatis, vix obconicis, haud transversis, validis, articulo ultimo ovata-conico, acuminato, 1 ad 5 nitidis, parum pubescentibus, 6 ad 11 breviter pubescentibus, opacis. Prothorace valde anticem rotundate, posticem emarginate attenuato, loco latissimo in $\frac{2}{3}$ a basi sito rotundato, prothorace sat convexo, angulis posticis carinatis et impressis, ante basin 4 magnis foveis rotundis, earum internis sibi haud approximatis, spatio elevato disiunctis. Elytris ellipticis, sat, arcuate dilatatis et attenuatis, humeris validis, obtusatis, impressione basali distincta, haud profunda, posticem obsoleta, in ea fovea suturali et humerali conspicua, iis posticem elongatis, sutura utrinque basi elevata, apice elytrarum oblique abscisso, pygidio longo. Pedibus mediocribus, longis, tibiis haud multum incrassatis, trochanteris posticis longe clavatis, pedibus luteo-castaneis, breviter pubescentibus, tarsis validis, longis, apud ♂ anticis et mediis parum dilatatis. Metasterno ♀ convexo, medio deplanato, ♂ medio ad coxas posticas valde distantes 3-angulariter arcuatis marginibus plane impresso, margine postica metasterni recta. Metasterno et sternitis fere glabris, sat longe, rarius luteo-grisee pubescentibus, sternito 2 longissimo, sequentibus simplicibus (Tab. 1, fig. 12).

Dimensiones

	mm.
Capitis:	
Longitudo	0.26
Latitudo maxima	0.46
Latitudo basi	0.26
Prothoracis:	
Longitudo	0.48
Latitudo maxima	0.51
Latitudo antice	0.31
Elytrarum:	
Longitudo (sine pygidio)	1.16
Latitudo basi	0.48
Latitudo maxima	0.83
Longitudo pygidii	0.21
Longitudo oculorum	0.09
Articuli palporum praeultimi:	
Longitudo	0.15
Latitudo	0.06
Articuli palporum ultimi:	
Longitudo minus quam	0.01
Latitudo minus quam	0.01
Longitudo corporis	2.11

Dimensiones—Continued.

Articuli antennarum:	Long. mm.	Lat. mm.
I.	0.16	0.05
II.	0.06	0.04
III.	0.06	0.04
IV.	0.06	0.04
V.	0.08	0.04
VI.	0.05	0.04
VII.	0.04	0.05
VIII.	0.03	0.04
IX.	0.13	0.11
X.	0.11	0.11
XI.	0.16	0.11
Longitudo antennarum	0.94	

The formation of the antennæ, of the apex of the elytra and pygidium gives to this remarkable species an isolated position among the other species of the Philippines and the Indomalayan islands.

In the following key I have summarized the characters of the species described in this paper:

Genus *Cephennodes* Reitter.

a^1. Long. 1.29 mm. Stria interhumerali 0.5 longitudinis elytrarum attingente. Antennis longis, 0.68 mm. *Cephennodes luzonicus* sp. nov.

a^2. Long. 0.99 mm. Stria interhumerali $\frac{1}{3}$ longitudinis elytrarum attingente. Antennis brevibus, 0.49 mm. *Cephennodes bakeri* sp. nov.

Genus *Napochus* Reitter.. *Napochus bakeri* sp. nov.

Genus *Euconnus* C. G. Thomson.................... *Euconnus bakerianus* sp. nov.

Genus *Scydmaenus* Latr. Characteristica ex parte communia: Articuli antennarum 7 et 8 seu 8 olim intus attenuati, trochanteri postici longi.

a^1. Prothorace structura nulla. Long. 1.94 mm. *Scydmeanus bakeri* sp. nov.

a^2. Prothorace structura praesente.

b^1. Prothorace basi foveis duabus. Long. 1.89 mm. *Scydmaenus bakerianus* sp. nov.

b^2. Prothorace basi foveis quattuor.

c^1. Foveis internis distantibus, elytris dense rugose punctatis. Long. 2.02 mm. .... *Scydmaenus banahao* sp. nov.

c^2. Foveis internis maxime distantibus, elytris microscopiter punctulatis. Long. 1.94 mm. ..... *Scydmaenus maquilingensis* sp. nov.

c^3. Foveis internis distantibus, elytris microscopiter punctulatis. Long. 2.32 mm. .... *Scydmaenus sibuyani* sp. nov.

c^4. Foveis internis elevato spatio disiunctis, elytris rare et grosse punctatis. Long. 2.11 mm. .... *Scydmaenus luzonicus* sp. nov.

b^3. Prothorace foveis basi duabus, ante basin quattuor. Long. 2.12 ad 2.20 mm. .... *Scydmaenus tangcolan* sp. nov.

b^4. Prothorace basi foveis quattuor, basi medio stria brevi. Long. 2.19 mm. .... *Scydmaenus philippinicus* sp. nov.

Table 1 indicates the measurements of the parts of the corpus of the individual species, and these figures form the basis for the graph shown as Plate 1. It may be necessary to control by further measurements whether the above figures, especially the last one, are permanent for one group of species of one genus, and for species of one territory.

PRAGUE, *December, 1927.*

TABLE 1.—*Relation among the measurements of parts of the corpus of Philippine species of Scydmaenidæ.*

Species.	Head.	Prothorax.	Elytra.	Corpus.
Cephennodes luzonicus	0.36	0.57	1.31	2.05
Cephennodes bakeri	0.27	0.71	1.09	1.87
Napochus bakeri	0.66	0.69	1.32	2.15
Euconnus bakerianus	0.79	1.19	1.18	2.22
Scydmaenus bakerianus	0.80	1.13	1.63	2.86
Scydmaenus bakeri	0.87	1.12	1.75	2.93
Scydmaenus banahao	0.63	1.14	1.58	2.73
Scydmaenus tangcolan	0.75	0.89	1.59	2.65
Scydmaenus sibuyani	0.86	1.13	1.53	2.60
Scydmaenus maquilingensis	0.73	1.24	1.39	2.55
Scydmaenus philippinicus	0.71	1.15	1.39	2.46
Scydmaenus luzonicus	0.56	0.94	1.65	2.54

Genus	Head.	Prothorax.	Elytra.	Corpus.	Average number.
Cephennodes	0.31	0.64	1.20	1.96	1.027
Napochus	0.66	0.69	1.32	2.15	1.180
Euconnus	0.79	1.19	1.18	2.22	1.345
Scydmaeni philippinici (8 species)	0.73	1.09	1.56	2.66	1.510
Scydmaeni sumatrenses (8 species)	0.78	1.15	1.58	2.82	1.582

ILLUSTRATIONS

[The illustrations are taken with the Abbé drawing apparatus and the Steindorfer microscope, ocular 3, objective 8.]

PLATE 1

FIG. 1. *Cephennodes luzonicus* sp. nov., male.
2. *Cephennodes bakeri* sp. nov.
3. *Napochus bakeri* sp. nov., female.
4. *Euconnus bakerianus* sp. nov., male.
5. *Scydmaenus bakerianus* sp. nov., male.
6. *Scydmaenus bakeri* sp. nov., female.
7. *Scydmaenus banahao* sp. nov., male.
8. *Scydmaenus tangcolan* sp. nov., male.
9. *Scydmaenus maquilingensis* sp. nov., male.
10. *Scydmaenus sibuyani* sp. nov., male.
11. *Scydmaenus philippinicus* sp. nov., male.
12. *Scydmaenus luzonicus* sp. nov., male.

PLATE 2

A graphic indication of the relation between I, length and breadth of head; II, prothorax; III, elytra; and IV, corpus of species of Philippine Scydmaenidæ. These relations are shown by points joined by lines. On the axis X is the relation (shield, head, etc.) on the axis Y the size of the relation number. With the individual species there is considerable homogenity, and lack of comparison for *Euconnus* and *Napochus*, due to these being represented by one species only.

A. *Cephennodes luzonicus* sp. nov.
B. *Cephennodes bakeri* sp. nov.
C. *Napochus bakeri* sp. nov.
D. *Euconnus bakerianus* sp. nov.
E. *Scydmaenus bakerianus* sp. nov.
F. *Scydmaenus bakeri* sp. nov.
G. *Scydmaenus banahao* sp. nov.
H. *Scydmaenus tangcolan* sp. nov.
I. *Scydmaenus sibuyani* sp. nov.
K. *Scydmaenus maquilingensis* sp. nov.
L. *Scydmaenus philippinicus* sp. nov.
M. *Scydmaenus luzonicus* sp. nov.

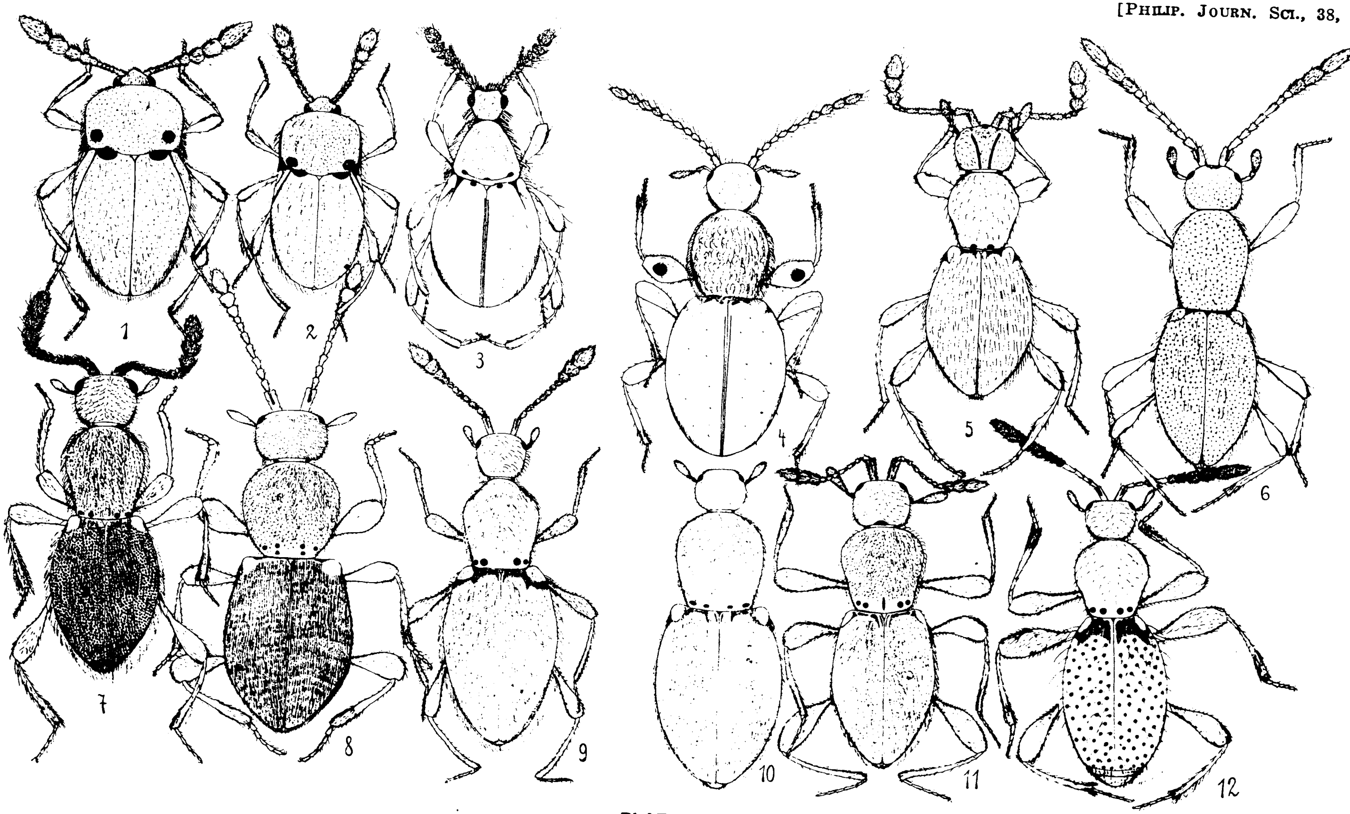

PLATE 1.

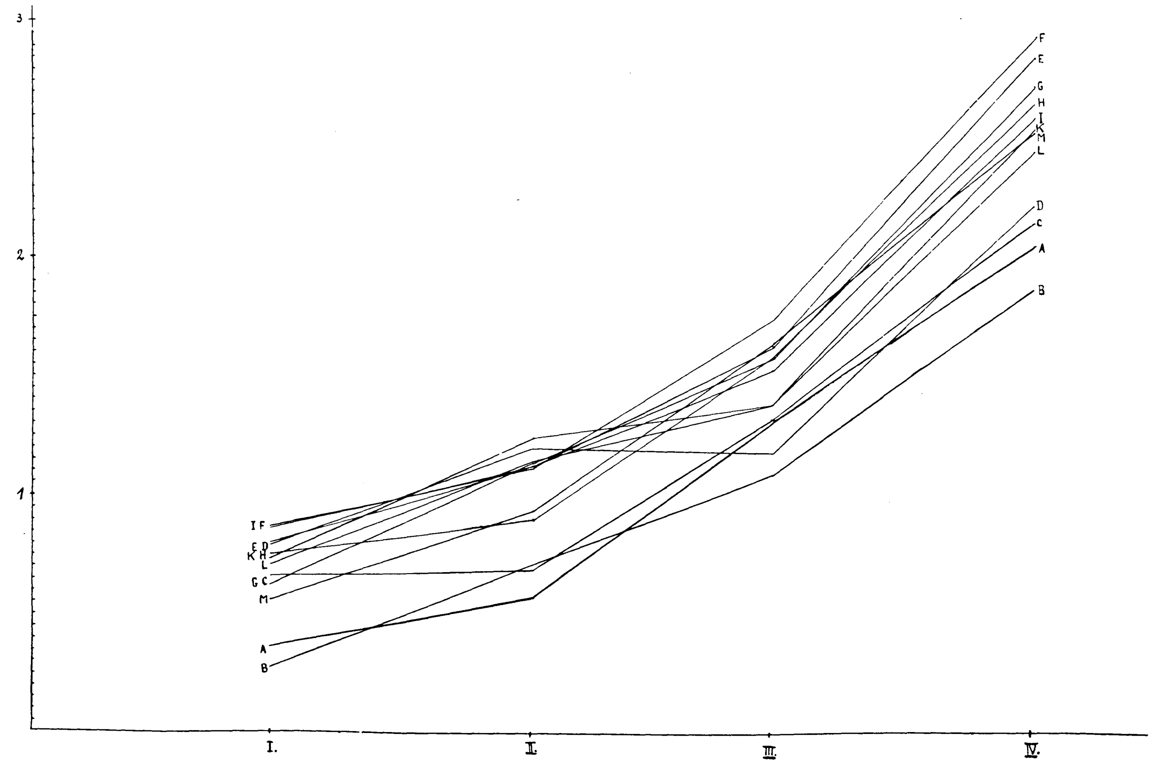

PLATE 2.

THEREVIDEN (DIPTERA) VON DEN PHILIPPINEN AUS JAPAN UND FORMOSA

Von O. KRÖBER

Hamburg, Deutschland

EINE TAFEL

Eine kleine Thereviden Ausbeute, die mir kürzlich Herr C. F. Baker zur Determination sandte, veranlasst mich die Fauna dieser drei, wie es scheint recht isoliert liegenden Gebiete zusammenfassend zu veröffentlichen. Drei Arten von den Philippinen, zwei von Japan, und fünf von Formosa liegen bisher vor. Die ersteren weisen entschieden auf die australische Fauna hin, die japanischen auf die palaearktische, die letzteren auf die orientalische.

PSILOCEPHALA LATERALIS Eschscholtz. Tafel 1, Fig. 1.

Psilocephala lateralis ESCHSCHOLTZ, Entom. 1 (1882) 112.

Erkennbar an dem ganz schwarzen vierten Tergit, worauf meines Wissens zum ersten Mal von Osten-Sacken hingewiesen wurde.[1] Die zweite Spezies, die dort erwähnt wird, liegt mir auch vor, scheint neu zu sein, da keine der vorliegenden Beschreibungen der orientalisch-australischen Region darauf passt. Bezzi hat sie als *albina* Wied. aufgefasst was mit der Type nicht stimmt, es sei denn dass diese vollkommen denudiert ist und daher das Erkennen der Art unmöglich macht. Ich nenne sie dem Sammler zu Ehren. *Psilocephala lateralis* ist aus einem grossen Teil der australischen Inselwelt bekannt geworden, auch schon früher von Manila erwähnt worden. ♂, Länge, 9.5 bis 11; Fühler, 1.5 bis 1.6; Flügellänge, 8 bis 9.5; Flügelbreite, 3 mm. Tadellos erhalten. Augen haarfein getrennt. Ocellenhöcker weissgrau mit drei roten Ocellen. Aeusserstes Stirndreieck mit schwarzen Reflexen. Erstes Fühlerglied grau, silberweiss tomentiert, lang schwarz beborstet; zweites und drittes bräunlich; zweites kugelig, borstig; drittes lang kegelig, wit wenigen Borsten im untern Teil und im Spitzenteil deutlich und dicht fein kurz behaart. Endgriffel deutlich zweigliedrig mit feiner Endborste. Taster mit ausserordentlich langer weisser

[1] Berlin Ent. Zeitschr. 26 (1882) 113.

Behaarung, die bei flüchtiger Betrachtung ein behaartes Untergesicht vortäuschen. Behaarung fast am ganzen Körper schneeweiss. Thorax mit einer rein zimtbraunen Längsstrieme, die sich nach vorn verschmälert und fein weisslich eingefasst ist. Schildchen weissgrau mit schwärzlichem Basalfleck; vier Randborsten. Schüppchen weisshyalin. Schwinger schwarzbraun. Beine schwarzbraun, Schenkel fast schwarz, glänzend silberweiss behaart. Borsten und Haftläppchen schwarz. Flügel absolut hyalin. Adern sehr zart. Vierte Hinterrandzelle geschlossen und kurz gestielt. Randmal gross, schwarzbraun. Die Längsadern können an der Spitze leicht gebräunt sein. Hinterleib silberweiss und tief schwarz. Erster Ring schwarz, durch Toment grau, mit langer weisser Behaarung. Zweiter und dritter am Vorderrand fast bis zur Hälfte rein schwarz, parallelrandig begrenzt, in der Mitte ein klein wenig dreieckig vorgezogen. Vierter Ring ganz schwarz. Zweiter bis sechster mit feinem, weissgelbem, seidigem Saum, der nur in Seitenansicht sichtbar wird. Fünfter bis siebenter silberglänzend, seitlich lang, dicht, auffällig, weiss und gelbweiss wollig behaart, was um so auffälliger wirkt weil der vierte Ring und die Genitalien vollkommen schwarz behaart sind. Die schwarzen Querbinden sind auch schwarz behaart. Bauch schwarz. Erstes bis viertes Sternit mit grauem Schein; zweites bis viertes mit weissgelbem Saum. Analsegment schwarz mit zwei schwarzen Zangen und zwei mittleren rötlich schimmernden Griffeln. Auch von unten erscheinen alle Anhänge rötlich. Die letzten Sternite erscheinen manchmal wie eine schwarze Bürste. Die schneeweissen Haarsäume des fünften bis siebenten Tergits scheinen sehr hinfällig zu sein. Die Genitalien sind manchmal fast rostgelb. Im allgemeinen ist der Silberglanz sehr stark, bläulich. ♂, liegen mir vor von Sibuyan, Polillo (leg. *C. F. Baker*), Neu Britannia, Kei-Inseln, Neu Guinea, Friedrich Wilhelm Hafen, Berliner Hafen, Sattelberg am Huongolf, Triana an der Astrolabe Bay. Mioko, Duke of York; Salomon Archipel, Shortlands Inseln. Dies letzte ♂ misst nur 7 mm., offenbar frisch geschlüpft, mit braunen Beinen.

♀, Untergesicht weisslich bestäubt. Stirn oberhalb der Fühler hellgrau. Die obere Partie trägt zwei matte schwarze Längsstriemen, die nach unten divergieren und durchaus kurz und dicht schwarz behaart sind. Kopf sonst wie beim ♂. Der untere Teil der Stirn ist schwarzbraun behaart. Thorax im Grunde schwarzbraun, glänzend, mit zwei silberweissen Längsstriemen, die bis zum Schildchen durchgehen. Schildchen sil-

bergrau mit schwarzem Mittelfleck. Hinterleib glänzend schwarz. Zweiter und dritter Ring hinten mit breiter grauer Binde, die sich seitlich erweitert und in der Mitte mehr oder weniger verdunkelt ist. Vierter Ring ganz schwarzbraun, fünfter und sechster ganz grau, siebenter in der Mitte schwarz, an den Seiten grau. Behaarung auf den ersten Ringen weiss, auf den letzten schwarz. Bauch schwarz, wenig glänzend. Zweites bis viertes Sternit mit gelblichem Saum. Fünftes bis siebentes Bürstenartig schwarz behaart. Beine schwarz, Mittleschienen an der Basis mehr oder weniger gelbbraun. Schenkel weiss behaart. Flügel blass bräunlich tingiert, mit ganz unscharfen aber breiten Säumen der Adern. Randmal schwarzbraun. Vierte Hinterrandzelle geschlossen. Neu Britannia, Manila, Kei Inseln, Friedrich Wilhelm Hafen, Mioko, Duke of York.

PSILOCEPHALA BAKERI sp. nov.

♂. Länge, 8 bis 10; Fühler, 1.3; Flügellänge, 8 bis 8.4; Flügelbreite, 2.5 bis 3 mm.

Gleicht in allem *P. lateralis,* aber der Hinterleib ist ganz anders. Augen haarfein getrennt. Rüssel Unterseits der Länge nach bräunlich gelb. Endgriffel scheinbar eingliedrig, da das sehr kleine linsenförmige Grundglied nicht in jeder Lage erkennbar ist. Das dritte Glied ist gleichfalls dicht kurz anliegend weissgelb behaart. Das erste Glied ist weniger stark beborstet als bei *lateralis.* Hinterleib äusserst dicht weiss behaart. Zweiter bis vierter Ring mit schmaler, glänzend schwarzer Vorderrandbinde; fünfter bis sechster am Vorderrand kaum etwas dunkler. In tadellosen Exemplaren ist die Behaarung so dicht und bläulich silberglänzend, dass von der Grundfarbe ausser den schwarzen Binden nichts zu erkennen ist. Zweites und drittes Sternit mit schwarzer Binde; viertes silberweiss; fünftes bis siebentes schwarz. Analsegment weiss bestäubt, sonst ähnlich gebaut wie bei *lateralis.* Die Klappen scheinen am Grunde breiter verbunden, die Griffel sind oben silberweiss.

Mindanao, Kolambugan, Davao, Dapitan. Leg. *C. F. Baker.*

PSILOCEPHALA sp.

♂. Sehr schlecht erhalten, feucht, voll Schimmel, die Augen grösstenteils zerfressen. Sie stiessen vollkommen zusammen. Erstes Fühlerglied schwarzgrau, zweites und drittes rotbraun. Stirndreieck und Untergesicht silberweiss. Taster und Rüssel schwarz (?), weiss behaart. Thorax und Hinterleib schwarz, mit Resten weisser Behaarung. Schwinger rotgelb. Schenkel

schwarz. Schienen und Tarsen hell gelbbraun. Flügel hyalin; Adern sehr, zart, gelblich. Vierte Hinterrandzelle geschlossen und gestielt. Stigma gelblich. Zweites und drittes Tergit mit gelblichem Saum.

Philippinen.

Aus Formosa sind die ersten Thereviden durch die Sammeltätigkeit Sauters bekannt geworden, zwei Gattungen mit fünf Arten, die aber die japanische Fauna recht nett ergänzen und deren Beschreibungen ich hier folgen lassen will, da dieselben ziemlich zersteut sind.

PHYCUS KERTESZI Kröber.

Phycus kerteszi KRÖBER, Deutsche Entom. Zeitschr. (1912) 4.

♂, glänzend schwarz, wie lackiert; ganz kurz silberweiss behaart und tomentiert. Stirn oberhalb der Fühler schwarz, etwas vorgewölbt, der Rest silberweiss, gleich dem Untergesicht. Fühler rein schwarz. Hinterkopf glänzend schwarz, seidig, am Rand weiss; Borsten schwarz. Thorax glänzend schwarz mit breiter, matter, weissgrauer Mittelstrieme. Schildchen glänzend schwarz, ebenso die Brustseiten, die Silberschimmer tragen. Hinterleib ganz glänzend schwarz; zweiter und dritter Ring mit seidigem Saum. Behaarung äusserst spärlich, auf den ersten Ringen weiss, auf den letzten schwarz. Beine durchaus glänzend schwarz, nur die Knie mehr oder weniger gelbbraun. Flügel absolut hyalin. Die ganze Spitze von der Mundung der zweiten Längsader an intensiv rauchgrau. Vierte Hinterrandzelle geschlossen. Länge, 9 bis 9.5 mm.

♀, gleicht dem ♂ bis auf die Geschlechtsmerkmale vollkommen.

Formosa. Type, Budapest.

Genus PSILOCEPHALA Zett

Bisher liegen vier Arten vor, die sich folgendermassen unterscheiden lassen:

♀, 1. Stirn mit glänzend schwarzer Schwiele .... *P. sauteri* Kröber.
Stirn ohne glänzende Schwiele .... 2.
2. Stirn mit dunkler Querbinde .... *P. frontata* Kröber.
Stirn und Scheitel glanzlos schwarz .... *P. obscura* Kröber.

♂, 1. Augen vollkommen zusammenstossend. Im äussersten Stirndreieck liegen schwarze Flecke .... *P. frontata* Kröber.
Augen haarfein getrennt .... 2.
2. Thorax mit brauner Mittelstrieme .... *P. sauteri* Kröber.
Thorax mit zwei weissen Linien .... *P. argentea* Kröber.

PSILOCEPHALA ARGENTEA Kröber.

Psilocephala argentea KRÖBER, Deutsche Entom. Zeitschr. (1912) 128.

♂. Sehr ähnlich *Thereva annulata* Fabricius. Durchaus schneeweiss behaart, nur alle Seten schwarz. Kopf ganz schneeweiss tomentiert. Fühler schwarz. Augen eigentümlich metallisch grün. Borstenkranz am hintern Augenrand schwarz, sehr zart. Thorax silbergrau tomentiert mit zwei weisslichen Längslinien. Schwinger weisslichgelb, Basis des Knöpfchens schwärzlich. Das zweite Tergit scheint unter der dichten Behaarung einen weissen Saum zu haben. Bauch seidig grau. Zweites bis fünftes Sternit mit hellem Saum. Schenkel schwarz, dicht schneeweiss behaart. Schienen und Tarsen hell gelbbraun, die Spitzen verdunkelt. Flügel absolut hyalin. Randmal blassgelblich. Vierte Hinterrandzelle geschlossen. Länge, 10 mm.

Formosa, Banshoryo, Tainan, V–VII. Type, Budapest.

PSILOCEPHALA SAUTERI Kröber.

Psilocephala sauteri KRÖBER, Deutsche Entom. Zeitschr. (1912) 135.

♂, Kopf auffallend gross. Fazetten in den obern zwei Dritteln bedeutend grösser als im untern. Stirn und Untergesicht schneeweiss, glänzend. Fühler schwarz, schwarz beborstet. Hinterkopf schneeweiss, schwarz beborstet. Borstenkranz äusserst kurz. Thorax hellgrau mit hellbrauner Mittelstrieme, die wieder durch eine dunkelbraune Linie getrennt ist, und von zwei weisslichen, ziemlich scharf begrenzten Linien begleitet wird. Behaarung am ganzen Körper schneeweiss. Alle Seten schwarz. Zweites Tergit oder zweites bis fünftes mit seidigem Saum; zweites bis sechtes seitlich mit kleinen schwarzglänzenden Fleck. Bauch im Grunde schwarz, silbergrau schimmernd. Brustseiten silbergrau. Schwinger schwarz. Schenkel schwarz. Schienen und Tarsen dunkelbraun, die Spitzen verdunkelt. Flügel schwach bräunlich tingiert. Randmal hellbraun. Vierte Hinterrandzelle geschlossen. Augen leuchtend goldgrün. Länge, 6.5 bis 9.5 mm.

Formosa, Takao, 24.6 bis 7.7.

♀, Stirn oben und Scheitel glänzend schwarz, unten scharf abgeschniten. In der Mitte ist unten ein kleines Dreieck ausgeschnitten, das gleich dem Untergesicht schneeweiss ist. Fühler schwarz grau bestäubt, schwarz beborstet. Thorax im Grunde schwarzbraun mit zwei weiss schimmernden, scharf begrenzten Längslinien. Behaarung äusserst sparsam, weisslich.

Schildchen grau mit braunem Mittelfleck. Brustseiten silbergrau, sparsam weiss behaart. Hinterleib schwarz, glänzend. Erster Ring ganz oder seitlich grau pubescent, weissgrau behaart. Zweiter und dritter Ring mit silberweisser Tomentbinde, die seitlich etwas erweitert ist. Vierter Ring ganz schwarz, mit kleinem, dreieckigen silberweissen Seitenfleck. Fünfter und sechster fast ganz silberweiss, mit schwärzlicher Mittelstrieme. Siebenter und achter glänzend schwarz. Behaarung auf den ersten Ringen äusserst sparsam und kurz, weisslich; auf den letzten beiderseits kurz abstehend schwarz. Bauch schwarz, kaum glänzend, mit weisslichgrauen Tomentbinden auf den ersten Ringen. Die letzten Ringe ganz schwarz. Schwinger schwärzlich mit hellem Stiel. Beine schwarzbraun; Basis der Schienen mehr oder weniger hellbraun. Flügel leicht braun tingiert. Randmal ziemlich scharf begrenzt, schwarzbraun. Vierte Hinterrandzelle geschlossen und kurz gestielt. Länge, 9 bis 11 mm.

Abnormes Geäder kommt vor; überzählige Aderstücke; vierte Randzelle in beiden Flügeln verschieden, selbst offen.

Formosa, Anping, Kankau, Banshoryo, V. bis VII.

Type, ♂, ♀, Budapest.

PSILOCEPHALA FRONTATA Kröber, ♂, ♀.

Psilocephala frontata KRÖBER, Deutsche Entom. Zeitschr. (1912) 123; Entom. Mitt. 2 (1913) 276.

♂, sehr ähnlich *P. sauteri,* aber robuster. Kopf nicht auffallend gross. Augen zuweilen leuchtend grün, die obern zwei Drittel nicht auffallend grösser fazettiert. Stirndreieck silberweiss, aber im äussersten Winkel mit zwei schwarzen Strichen oder ganz schwarz. Untergesicht silberweiss. Rüssel und Taster weissgrau, letztere lang schneeweiss behaart. Hinterkopf hell, weissgrau, zart weiss behaart. Borstenkranz schwarz. Thorax weissgrau mit breiter brauner Strieme, die durch weisse Linien eingefasst ist. Behaarung äusserst zart, abstehend schwarz und anliegend weiss. Brustseiten silbergrau, weiss behaart. Schildchen weissgrau mit brauner Mittellinie. Schwinger schwarz, Knöpfchenspitze weiss. Hinterleib durchaus weissgrau mit wundervollen Metallglanz. Zweiter bis fünfter Ring mit weissglänzendem Saum. Behaarung rein weiss. Bauch schwarzgrau. Zweites bis fünftes Sternit mit weissem Saum. Schenkel schwarz, Schienen gelbbraun, die äusserste Spitze schwarz. Tarsen schwarz, Basis der Metatarsen mehr oder weniger dunkel gelbbraun. Flügel fast hyalin, kaum et-

was bräunlich tingiert. Randmal deutlich. Vierte Hinterrandzelle geschlossen, selten offen. Adern stark. Länge, 8.5 bis 12 mm.

Formosa, Tainan, Kankau, Banshoryo.

♀, Untergesicht und Stirn oberhalb der Fühler seidig weiss, der Rest matt braun tomentiert. Die Grenze beider Farben bildet ein sammetschwarzes Band. Behaarung der Stirn schwarz, kurz, zerstreut. Fühler schwarzbraun, zweites Glied und Basis des dritten rötlich erscheinend. Hinterkopf schiefergrau, schwarz, beborstet, schneeweiss behaart. Borstenkranz schwarz. Thorax matt gelbbraun mit dunkelbrauner Längsstrieme, die durch zwei unscharfe helle Striemen eingesäumt ist. Schildchen gleich dem Thorax; Mitte dunkelbraun. Brustseiten weisslichgrau, spärlich weiss behaart. Schwinger schwärzlich, Stielbasis und Knöpfchenspitze weisslichgelb. Hinterleib schwarzbraun, etwas glänzend. Vom zweiten Ring an mit weisslichgrauen, dreieckigen Tomentseitenflecken. Zweiter und dritter Ring mit seidigem Saum. Behaarung äusserst spärlich, weiss. Fünfter bis achter Ring beiderseits kurz abstehend schwarz behaart. Bauch im grunde schwarz, matt, mit grauen Schimmer. Erstes bis drittes Sternit spärlich weiss behaart. Schenkel grau tomentiert, in Grunde schwarz, äusserst sparsam weiss behaart. Schienen und Tarsen hell gelbbraun mit dunklen Spitzen. Borsten schwarz. Flügel bräunlich tingiert, auffallend lang, den Hinterleib stark überragend. Randmal kaum etwas dunkler. Vierte Hinterrandzelle geschlossen. Länge, 8.5 bis 12 mm.

Formosa, Kankau (Koshun), Tainan, Banshoryo (Shisha), Anping, 5.6.

Type, ♂, Dahlem; ♀, Budapest.

PSILOCEPHALA OBSCURA Kröber, ♀.

Psilocephala obscura KRÖBER, Suppl. Entom. 1 (1912) 25.

Mässig erhalten, weil feucht gewesen! Kopf ziemlich gross. Augen mit schön blaugrünem Schein. Stirn schmal, glänzend schwarz, ohne Schwiele. Untergesicht und Partie neben den Fühlern silberweiss glänzend. Fühler sehr schlank; drittes Glied mit auffallend lang zugespitztem Griffel. Rüssel weiss behaart. Hinterkopf grauschwarz, ganz wenig glänzend. Borstenkranz schwarz. Behaarung weiss. Rückenschild und Hinterleib tiefschwarz, glanzlos (ob in tadellosen Exemplaren auch?), mit dichter fast weisser Behaarung. Zweiter Ring mit

Spuren eines weiss seidigen Saumes. Die weisse Behaarung bildet am zweiten bis vierten Ring einen dreieckigen Seitenfleck. Fünfter bis achter Ring kurz abstehend schwarz behaart. Bauch schlicht schwarz, ohne helle Säume, weisslich behaart. Schwinger schwarzbraun, Knöpfchenspitze gelblich. Hüften und Schenkel schwarz, durch anliegende gelbliche Behaarung grau erscheinend. Schienen hell rotgelb, die äusserste Spitze tiefschwarz. Tarsen schwarz. Basis der Metatarsen mehr oder weniger gelbbraun. Flügel ganz zart gelblich tingiert. Randmal gross, gelbbraun. Adern kräftig, braun. Vierte Hinterrandzelle ganz kurz gestielt. Länge, 12 mm.

Formosa, Anping, V. Type, ♀, Dahlem.

Aus Japan selber sind bisher nur zwei Thereviden bekannt geworden, von denen eine typisch palaearktisch ist: *Thereva subfasciata* Schummel, von der mir ein ♀ vorliegt; die zweite Art ist *Tabuda albata* Cogn., als *Psilocephala* beschrieben. Sonst finden eine ganze Anzahl palaearktischer Formen ihre Verbreitungsgrenze erst am Amur, keine weitere aber scheint weiter nach Osten zu reichen.

THEREVA SUBFASCIATA Schummel, ♂, ♀.

♂, goldgelb bis goldbraun behaart. Schenkel schwarz, Bauch schwarz. Flügel hyalin ohne jede Fleckung. Hinterleib ohne jede Schwarzfleckung, in Grunde graugrün, in gut erhaltenen Tieren gelbbraun mit grünen Auflug. Zuweilen mit einer aus schwarzen Haaren bestehenden Mittelstrieme, stets mit schwarzen Haaren an den Seiten der Einschnitte, besonders am ersten Tergit. Denudierte Exemplare mit vier weissgelben Säumen. Stirndreieck goldgelb.

♀, Hinterleib durchaus goldgelb anliegend behaart, ohne schwarze Binden; nur das achte Tergit glänzend schwarz. Länge, ♂, ♀, 9 bis 12 mm.

Type, ♂, Wien; ♀, Berlin.

Europa, Japan.

TABUDA ALBATA Cogn., ♂, ♀. Fig. 3.

Gleicht durchaus unserer *T. anilis* Fabricius, ist aber viel kräftiger in Colorit, das erste Fühlerglied ist minder geschwollen, Stirnbehaarung oberhalb der Fühler weiss, Zügel neben den Fühlern braun; Thorax mit vier braunen Striemen, Schienenspitzen schwarz.

♂, Länge, 8.4 bis 8.8; Fühler, 1.2; Flügellänge, 6.7; Flügelbreite, 2.3 bis 2.5 mm.

♀, Länge, 8.6 bis 9.8; Fühler, 1 bis 1.2; Flügellänge, 7.2 bis 8.6; Flügelbreite, 2.2 bis 2.9 mm.

Alle Exemplare von Kiushiu, Japan.

♂, Augen linienfein getrennt. Ocellenhöcker vorgequollen, gelbbräunlich tomentiert mit drei rotbraunen Ocellen. Stirn gelbseidig, mit weissgelber, seidiger Behaarung. Fühler gelbbraun tomentiert, die Basalglieder stossen zusammen. Weniger beborstet als bei *anilis* eigentlich nur an der Spitze; am zweiten Tergit sind die schwarzen Borsten länger als das erste Glied. Zweites Fühlerglied kugelig, das dritte länger als das erste, schlank, mit eingliedrigem kurzem Endgriffel, der eine zentrale Borste trägt. Zwischen Fühler und Auge liegt ein gelbbrauner deutlicher Zügel, der weit mehr auffällt als bei *T. anilis.* Taster fadlich, gelb, lang weiss behaart. Untergesicht nackt. Kopf unten weissgrau, weiss behaart, oben der Hinterkopf weiss behaart, schwarz beborstet. Bei *T. anilis* ist der Borstenkranz bedeutend länger und stärker. Thorax mit vier dunkelbraunen Striemen (bei *anilis* drei). Behaarung zart anliegend, weisslich, seidig. Seten schwarz, auch die vier am Schildchen. Brustseiten schwarz, gelbgrau tomentiert. Hüften, Vorder- und Hinterschenkel schwarz mit gelbbrauner spitze. Mittelschenkel hell gelbbraun; an der Basis etwas verdunkelt. Hüften weiss behaart, and der Spitze einzelne starke schwarze Borsten. Schenkel gelbweiss glänzend tomentiert, weiss behaart, schwarz beborstet. Schienen gelbbraun mit schwarzen Spitzen und Dornen. Tarsen bräunlich, die Basis der Metatarsen gelbbraun (bei *anilis* sind die Schienen ganz gelb). Schüppchen gelb, Schwinger schwarzbraun mit gelben Stiel (bei *anilis* weissgelb). Flügel weisslichbraun tingiert, mit sehr starker brauner Aderung, besonders die Queradern. Stigma braun. Vierte Hinterrandzelle weit offen (anilis hat sehr blass tingierte Flügel mit sehr zarten gelblichen zweiten Tergit, bräunlichen Adern, von denen die Queradern durch Stärke und eventuell Säumung auffallen; das Stigma ist bleich). Hinterleib im Grunde schwarz, mit silberweissem, seidig metallischem, glänzendem Toment. Zweiter und dritter Ring mit feinem gelbem Saum. Bauch silbergrau, zweites bis sechstes Sternit mit weissgelbem Saum. Genitalien rötlichgelb; die obere Schuppe schwarzgrau, die zwei langen seitlichen Griffel vie bei *anilis.* Behaarung dieser Teile rötlich und weissgelb.

♀, Stirn vollkommen flach, seidig gelbbraun, kurz schwarz behaart. Ocellenhöcker kaum markiert mit drei Ocellen. Un-

terhalb liegt eine kleine Querwulst, dann folgt eine flache Aushöhlung. Partie oberhalb der Fühler weiss seidig, weiss behaart. An der Grenze beider Farben liegt jederseits ein kleiner hellbrauner Sammetfleck am Auge. Alles andere wie beim ♂, nur die Beborstung spärlicher, zarter, kürzer, der Zügel blasser. Hinterkopf unten weisslich, oben bleich gelbbraun; kurz spärlich weiss behaart, kurz schwarz beborstet (*T. anilis* hat keine Stirnwulst, keine weisse Stirnbehaarung. Zügel weniger auffällig, Behaarung und Beborstung viel stärker und dichter). Thorax zimtbraun mit vier dunkelbraunen Striemen. Behaarung spärlich, gelblich; Borsten schwarz. Schildchen gleich dem Thorax, mit dunklerer Mitte. Brustseiten und Hüften weissgrau, weiss behaart. Beine hell gelbbraun, schwarzborstig. Spitzen der Schienen und Tarsen schwärzlich. Hüften und Schenkel weiss behaart (bei *anilis* Beine ganz gelb). Hinterleib olivebraun, fast glanzlos; erster und zweiter Ring ganz grau tomentiert, sonst Hinterrand und Seitendreiecke. Zweiter Ring mit weiss seidigem Saum. Bauch silbergrau, zweites bis fünftes Sternit mit weissgelben Saum. Genitalien glänzend braunrot oder schwarz mit rotbraunem Borstenkranz. Alles andre wie beim ♂.

ILLUSTRATIONEN

TAFEL 1

FIG. 1. *Psilocephala lateralis* Eschscholtz, ♂; *a*, Fühler von oben; *b*, Genitalien von oben.

2. *Psilocephala bakeri* sp. nov., ♂; *a*, Fühler von oben; *b*, Genitalien von oben.

3. *Tabuda albata* Cogn., ♂; *a*, Fühler von oben; *b*, Analsegment von der Seite.

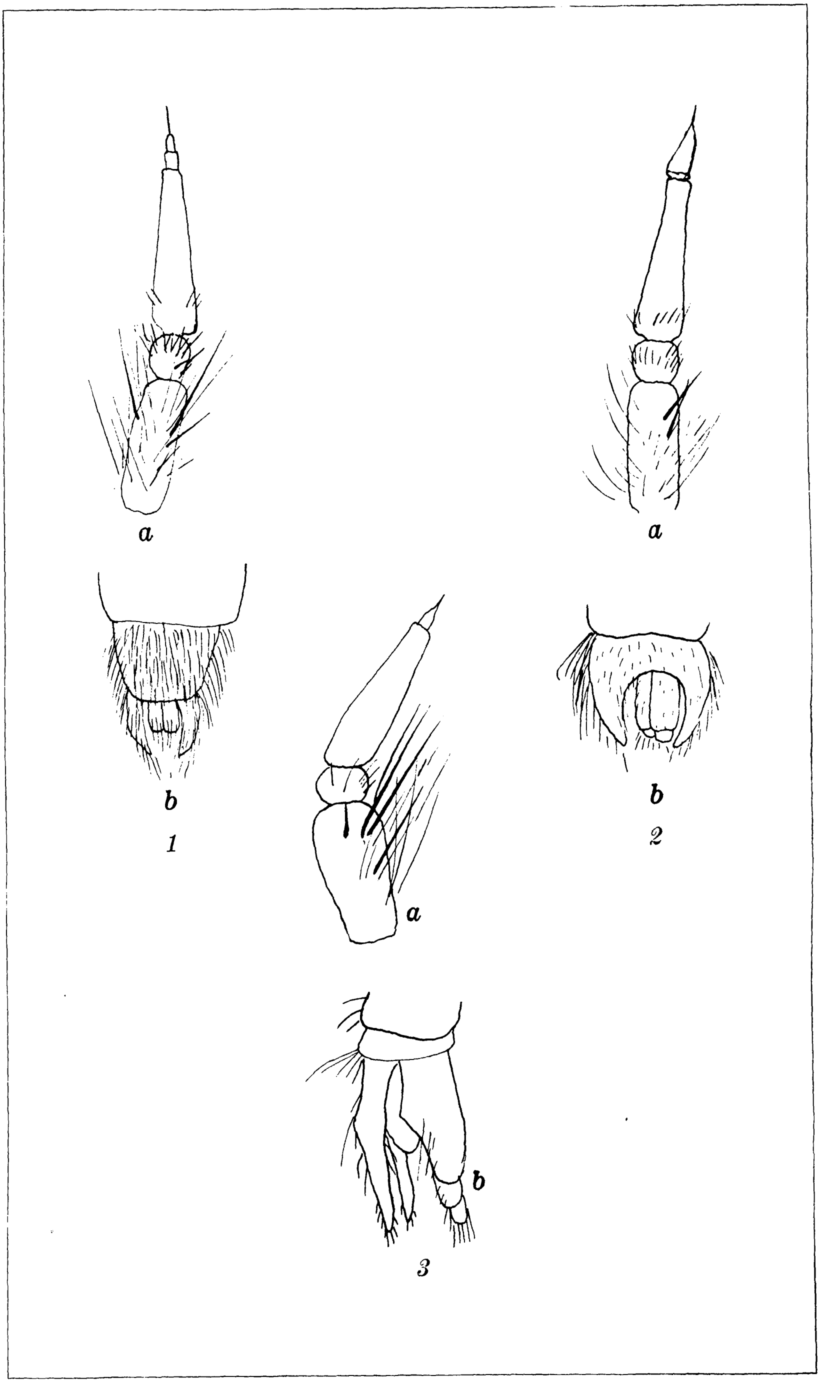

PLATE 1.

DIE STAPHYLINIDEN DER PHILIPPINEN

25. BEITRAG ZUR INDO-MALAYISCHEN STAPHYLINIDEN-FAUNA

Von MAX BERNHAUER

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Uebersicht ueber die Genera der Subtribus Lispini

1. Vorderhüften aneinander stehend, Vorderbrust rückwärts stumpfwinkelig abgeschnitten .... 2.
   Vorderhüften durch einen schmalen langen Fortsatz der Vorderbrust getrennt .... 3.
2. Kopf hinter den Augen nicht schmäler, ohne Halsbildung. *Paralispinus* Bernhauer.
   Kopf hinter den Augen schmäler, halsförmig abgesetzt. *Ischiopsaurus* g. nov.
3. Vorder- und Mittelschienen gegen die Spitze zu mit kurzen, dicken Dornen besetzt.......... *Pseudolispinodes* Bernhauer.
   Vorder- und Mittelschienen ohne solche Dorne.......... 4.
4. Körper in der Mitte erweitert, Zunge mit zwei dornförmigen Lappen. *Holosus* Motschulsky.
   Körper in der Mitte nicht oder kaum erweitert, Zunge mit drei dornförmigen Lappen.......... *Lispinus* Erichson.

Genus ISCHIOPSAURUS novum

Diese Gattung ist habituell der Gattung *Lispinus* Erichson sehr ähnlich, ist jedoch sofort durch die von einander nicht getrennten Vorderhüften zu trennen.

Körper gestreckt, wenig gewölbt, gleichbreit. Kopf viel schmäler als der Halsschild, hinten halsförmig abgeschnürt, mit seitlich stark vorstehenden Augen. Fühler gegen die Spitze kaum oder nur mässig, niemals keulig verdickt. Kiefer kurz, dick, die eine mit zwei kleinen Zähnchen. An den Kiefertastern ist wie bei *Lispinus* das vorletzte Glied sehr kurz, das letzte sehr gestreckt, mehr als dreimal so lang als das vorletzte. Auch die Kieferladen und die Lippentaster und die Zungenbildung mit den Paraglossen sind von *Lispinus* nicht wesentlich verschieden, insbesondere hat die Zunge die charakteristischen drei dornförmigen Lappen, von denen die zwei seitlichen schmäler als der mittlere sind. Das Kinn ist trapezförmig, nach vorn stark verengt. Halsschild herzförmig, vor den Hinterecken ausgeschweift. Flügeldecken sehr langgestreckt. Hinterleib ungeran-

det, seitlich ohne deutliche Schrägstriche. Tarsen fünfgliedrig, Schienen unbedornt bis auf die an der Spitze befindlichen.

Die Beschreibung ist nach der als *Lispinus* beschriebenen Art *colossus* Bernhauer von Madagaskar entworfen, welche schon durch die enorme Grösse von den beiden untenbeschriebenen Indo-malayischen Arten stark abweicht.

ISCHIOPSAURUS BOETTCHERI sp. nov.

Pechschwarz, glänzend, ziemlich flach, die Taster und Beine rostrot.

Kopf deutlich schmäler als der Halsschild, ohne Eindrücke, mässig stark und mässig weitläufig punktiert. Fühler eigenartig geformt, das zweite Glied kurz, quer, das dritte viel länger, jedoch nicht oblong, ungefähr so lang als breit, das vierte und fünfte gleichgebildet, knopfförmig, etwas breiter als lang, die folgenden bis zum zehnten verkehrt trapezförmig, das sechste bis achte Glied an Länge abnehmend, schwach quer, die folgenden an Länge zunehmend, und an Breite abnehmend, das zehnte nur wenig breiter als lang, das Endglied schmäler, wenig länger als das zehnte. Halsschild etwas schmäler als die Flügeldecken, wenig breiter als lang, vorn parallelseitig, nach rückwärts deutlich ausgeschweift verengt, vor den scharf rechtwinkeligen Hinterecken mit einem tiefen Eindruck, mit sehr schmaler, undeutlich gefurchten Mittellinie, stärker und weniger weitläufig als der Kopf, etwas ungleichmässig, gegen die Seiten feiner und weitläufiger punktiert. Flügeldecken um die Hälfte länger als der Halsschild, ein Drittel länger als zusammen breit, parallelseitig, neben der Naht scharf gefurcht, auf der Scheibe mit je einem starken Punkt, im übrigen deutlich stärker und dichter als der Halsschild, an den Seiten feiner und weitläufiger punktiert. Hinterleib gleichbreit, kräftig und ziemlich dicht, seitlich stärker und hie und da der Länge nach zusammenfliessend punktiert. Länge, 7 Millimeter.

MINDANAO, Mumungan (*Boettcher*). Ein einzelnes Stück.

ISCHIOPSAURUS CORDICOLLIS sp. nov.

Von der vorhergehenden Art durch fast dreimal so kleine Gestalt, sowie durch folgende weitere Unterschiede leicht zu trennen:

Der Kopf ist viel feiner und dichter punktiert, mit je einem deutlichen Grübchen neben den Fühlerhöckern, im Grunde deutlich chagriniert. Fühler länger, weniger dick, alle Glieder länger. Der Halsschild etwas polsterartig gewölbt, feiner und

viel dichter punktiert, im Grunde deutlich chagriniert, die Grübchen neben den Hinterecken kleiner und flacher. Die Flügeldecken viel feiner und weitläufiger, etwas deutlicher runzelig punktiert. Der Hinterleib endlich ist ebenfalls viel feiner und nur weitläufig, seitlich kaum längsrunzelig punktiert. Länge, 4.8 Millimeter.

SINGAPORE (*Baker*).

Auch von dieser Art liegt mir nur ein einziges Stück vor, welches ich der Güte meines lieben freundes Professor Baker verdanke.

Genus LISPINUS Erichson

1\. Körper schmal und sehr langgestreckt, niedergedrückt, die Flügeldecken mindestens um die Hälfte länger als der Halsschild (mit Ausnahme von *nitidipennis*), dieser flach, nicht oder kaum breiter als lang .... 2.

Körper weniger schmal oder kurz, Flügeldecken höchstens ein Drittel länger als der Halsschild (ausser *spectabilis*) .... 15.

2\. Die Längsfurchen vor den Hinterecken des Halsschildes reichen höchstens bis zur Mitte der Halsschildseiten .... 3.

Die Längsfurchen vor den Hinterecken des Halsschildes reichen über die Mitte der Halsschildseiten .... 6.

3\. Halsschild nach hinten stark verengt, die Hinterecken stumpf .... 4.

Halsschild nach hinten schwächer verengt, die Hinterecken scharf.... 5.

4\. Halsschild länger als breit, Flügeldecken fast um die Hälfte länger als zusammen breit. Von der normalen Färbung: pechschwarz mit rostroten Beinen, glänzend, überall äusserst fein aber deutlich chagriniert. Kopf mit zwei Grübchen zwischen den Fühlerhöckerchen, sehr fein und spärlich punktiert. Fühler mässig kurz, die vorletzten Glieder kaum quer. Halsschild fast so breit als die Flügeldecken, vorn parallelseitig, im letzten Drittel verengt, fein, aber deutlich punktiert, längs der Mittellinie schmal geglattet, die Eindrücke vor den Hinterecken schmal und tief, bis etwas über das letzte Drittel der Halsschildlänge nach vorne reichend. Flügeldecken mit zwei Punkten auf jeder Schiebe, ausser der Grundskulpter kaum punktiert, um die Hälfte länger als zusammen breit. Hinterleib seitlich mit scharfen Schräglinien besetzt. Länge, 6.5 mm. BORNEO, Sandakan (*Baker*) .... *L. longicollis* sp. nov.

Halsschild nur so lang als breit, Kopf etwas feiner punktiert, Fühler viel kürzer, die vorletzten Glieder stark quer, Halsschild etwas feiner punktiert, Flügeldecken nur um ein Drittel länger als zusammen breit. Länge, 5 bis 5.5 mm. BORNEO, Sandakan (*Baker*). *L. parallelus* sp. nov.

5\. Halsschild und Flügeldecken etwas gewölbt, ersterer sehr fein, letztere gar nicht punktiert (ausser den zwei grossen Punkten), nur chagriniert, Flügeldecken etwas weniger lang. Hinterleib seitlich mit zahlreichen und scharf eingegrabenen Schräglinien besetzt. Fühler kurz, die vorletzten Glieder stark quer. Länge, 5 mm. SIARGAO, Dapa (*Boettcher*) .... *L. dapanus* sp. nov.

Halsschild und Flügeldecken sehr flach, ersterer zeimlich kräftig und dichter, letzterer ausser den zwei grossen Punkten sehr fein, aber deutlich erkennbar, weitläufig punktiert, die Chagrinierung etwas weniger dicht. Flügeldecken etwas länger. Hinterleib seitlich mit weniger zahlreichen, schwächer und weniger schief eingegrabenen Schräglinien besetzt. Fühler länger, die vorletzten Glieder nur wenig quer. Länge, 5 bis 6.5 mm (je nach Streckung des Hinterleibes). PALAWAN, Binaluan (*Boettcher*).. *L. brevisulcatus* sp. nov.

6. Flügeldecken sehr stark und dicht chagriniert, mehr oder minder matt .... 7.

Flügeldecken weniger stark und dicht chagriniert, mehr oder minder glänzend .... 9.

7. Sehr gross (7.5 mm), Flügeldecken zeimlich dicht punktiert, ohne Subhumeralpunktreihe. Eine stattliche, durch die ziemlich starke und verhältnismässig dichte Punktierung und besonders lange Flügeldecken ausgezeichnete Art. Mässig glänzend, überall deutlich chagriniert. Kopf mit zwei tiefen und langen Längseindrücken, kräftig und ziemlich dicht punktiert. Fühler zeimlich kurz, die vorletzten Glieder stark quer. Halsschild fast so breit als die Flügeldecken, etwas länger als breit, an den Seiten sehr sanft gerundet, nach rückwärts schwach verengt, vor den rechtwinkeligen Hinterecken etwas ausgeschweift, neben der breiten geglatteten Mittellinie der Länge nach eingedrückt, an den Seiten in Fortsetzung der bis zur Mitte nach vorn reichenden Längsfurchen mit einem kurzen Längseindruck noch kräftiger als der Kopf und etwas dichter, ungleichmässig punktiert. Flügeldecken ausserordentlich lang gestreckt, mehr als um die Hälfte länger als der Halsschild, um die Hälfte länger als zusammen breit, neben der Naht im ersten Drittel mit einem kurzen Längseindruck, ausser den zwei stärkeren in einer Längslinie stehenden Punkten fein und verhältnismässig dicht, an der Naht spärlich punktiert. Hinterleib sehr gestreckt, an den Seiten mit zahlreichen scharfen und langen Schrägstrichen und ausserdem mit sehr feinen, spärlichen Pünktchen besetzt. LUZON, Balbalasang (*Boettcher*) .... *L. magnificus* sp. nov.

Mässig gross (5 bis 6 mm), Flügeldecken spärlich punktiert mit einer mehr oder minder deutlichen Subhumeralpunktreihe........ 8.

8. Grösser (5.5 bis 6 mm), die Chagrinierung sehr grob und sehr dicht, matter. MINDANAO, Dapitan (*Baker*). LUZON, Haight's Place, Trinidad, Mount Polis, Laguna (*Boettcher*).
L. lineatopunctatus sp. nov.

Kleiner (4.5 bis 5 mm), die Chagrinierung viel feiner und weitläufiger, wenig matt. LUZON, Mount Polis, Laguna (*Boettcher*).
L. l. montanus var. nov.

Vorstehende Art samt Varietät unterscheidet sich von *magnificus* mihi ausser durch die unter Leitzahl 7 beschriebenen Gegensätze noch durch folgende Punkte: Der Kopf ist halb so stark und weniger scharf punktiert, die Stirneindrücke schwächer, der Halsschild kürzer, so lang als breit, feiner und weitläufiger punktiert, die Seitenfurchen viel schmäler und bis hinten schärfer abgesetzt. Flügeldecken etwas weniger lang, viel feiner, weitläufiger und undeutlicher punktiert.

9. Halsschild stark glänzend, auch bei stärkster Lupenvergrösserung kaum sichtbar chagriniert .... 10.
   Halsschild nur mässig glänzend, bei stärkster Lupenvergrösserung deutlich chagriniert .... 11.
10. Flügeldecken deutlich chagriniert, Halsschild in der Mittellinie nicht gefurcht. Kopf mit zwei starken Stirneindrücken, fein und ziemlich weitläufig punktiert. Fühler ziemlich kurz, die vorletzten Glieder deutlich quer. Halsschild so lang als breit, etwas schmäler als die Flügeldecken, vor der Mitte am breitesten, nach vorn gerundet, nach rückwärts bis zu den rechteckigen Hinterwinkeln fast geradlinig verengt, längs der Mitte mit schmaler geglatteter Mittellinie, zu deren Seiten schwach niedergedrückt, etwas stärker und dichter als der Kopf punktiert, die Seitenfurchen scharf eingegraben, bis vor die Mitte nach vorn reichend. Flügeldecken ungefähr ein Drittel länger als zusammen breit, deutlich netzartig gewirkt, ausser den zwei stärkeren Punkten auf jeder Decke äusserst zart und spärlich punktiert, mässig stark glänzend. Hinterleib glänzend, die seitlichen Schrägstriche mässig kräftig. Länge, 4.5 mm. LUZON, Laguna, Los Baños (*Boettcher*). Ein einzelnes Stück.. *L. splendidicollis* sp. nov.
    Flügeldecken kaum sichtbar chagriniert, stark glänzend, Halsschild in der Mittellinie fein gefurcht. Kopf glänzender, etwas feiner punktiert, die Stirneindrücke viel schwächer. Halsschild nach rückwärts schwächer verengt, die Punktierung stärker und dichter. Flügeldecken etwas kürzer, etwas stärker punktiert. Hinterleib mit feineren und spärlicheren Schrägstrichen. Länge, 5 mm. LUZON, Balbalan (*Boettcher*). Ein einziges Stück.
    L. splendidipennis sp. nov.
11. Flügeldecken deutlich und nicht allzu spärlich punktiert, eine Subhumeralpuntreihe mehr oder minder deutlich sichtbar, Halsschild sehr kräftig punktiert. Kopf mit zwei starken Stirneindrücken fein und nicht zu weitläufig punktiert, Fühler mässig kurz, die vorletzten Glieder kaum quer. Halsschild länger als breit, vor den scharfen Hinterecken ausgeschweift, in der Mittelinie sehr fein gefurcht, kräftig und verhältnismässig dicht punktiert. Flügeldecken ein Drittel länger als zusammen breit. Hinterleib mit schwächeren, etwas undeutlichen, nicht sehr schrägen Längsstrichen an den Seiten. Von *lineatopunctatus* durch schwächere Chagrinierung, weniger matten Körper und viel stärkere Punktierung leicht zu unterscheiden. Länge, 5.2 bis 5.6 mm. LUZON, Bangui (*Boettcher*).
    L. medius sp. nov.

Die Art ist, wie es scheint, veränderlich, wenn die folgenden Formen nicht vielleicht selbstständigen Arten angehören:

a. Halsschild nicht länger als breit, Punktierung namentlich des Halsschildes kräftiger und dichter, Subhumeralpunktreihe sehr deutlich, LUZON, Benguet, Baguio (*Baker*). Ein einziges Stück.
L. medius punctus subsp. nov.

b. Von der Stammform durch kürzeren, feiner und weitläufiger punktierten Halsschild und deutlich kürzere Flügeldecken verschieden. LUZON, Bangui (*Boettcher*) .... *L. medius dubius* subsp. nov.

Flügeldecken ohne Spur einer Subhumeralpunktreihe, der Halsschild fast breiter als lang, stärker und beträchtlich dichter punktiert, Fühler viel kürzer, die vorletzten Glieder sehr stark quer, fast doppelt so breit als lang. Länge, 5.5 bis 6 mm. PALAWAN, Binaluan (*Boettcher*) .... *L. antennatus* sp. nov.

Flügeldecken ohne Subhumeralpunktreihe, Halsschild weniger kräftig punktiert .... 12.

12. Halsschild länger als breit, Flügeldecken um die Hälfte länger als zusammen breit .... 13.

Halsschild nicht oder kaum länger als breit........ 14.

13. Körper grösser, Flügeldecken äusserst fein, aber doch deutlich punktiert, Fühler kurz. Von *medius* Stammform durch bedeutend grössere Gestalt, den Mangel der Subhumeralpunktreihe, und bedeutend kürzere Fühler sofort zu trennen. Von *antennatus* mihi durch längere und feiner punktierten Halsschild, längere und feiner punktierte Flügeldecken verschieden. Die Art variiert etwas in der Länge des Halsschildes und der Flügeldecken und in der Stärke der Punktierung. Eine Anzahl von Stücken ist neben der Mittellinie des Halsschildes schwach längseingedrückt, so dass die Mittellinie etwas erhoben erscheint, wie denn überhaupt eine grosse Anzhal von Arten der zu den schwierigsten Staphylinidengenera gehörigen Gattung *Lispinus* zu grösserer Variabilität neigt. Länge, 6.5 mm. LUZON, Los Baños, Mount Isarog (*Boettcher*), Mount Maquiling (*Baker*). DINAGAT (*Boettcher*) .... *L. banosanus* sp. nov.

Körper kleiner, Flügeldecken nicht deutlich punktiert. Von *banosanus* überdies durch stärkeren Glanz des Körpers, längere Fühler, nicht quere vorletzte Fühlerglieder, und weitläufiger punktierten Halsschild verschieden. Länge, 5 bis 5.5 mm. LUZON, Mount Banahao (*Boettcher*) .... *L. longesulcatus* sp. nov.

14. Körper grösser. Halsschild vorn nicht schmäler als die Flügeldecken. Fühler schlank, die vorletzten Glieder nicht breiter als lang, Halsschild kräftig punktiert, Flügeldecken sehr lang, fast mehr als um die Hälfte länger als die Flügeldecken, deutlich chagriniert und deutlich punktiert. Länge, 6 mm. MINDANAO, Mumungan (*Boettcher*) .... *L. planicollis* sp. nov.

Körper kleiner, Halsschild vorn deutlich etwas schmäler als die Flügeldecken, Fühler mässig kurz, die vorletzten Glieder schwach quer, Halsschild meist mässig stark punktiert, Flügeldecken kaum um die Hälfte länger als der Halsschild, deutlich chagriniert und meist nur undeutlich punktiert. Länge, 5 bis 5.5. LUZON, Los Baños, Mount Banahao, Balbalan, Mount Isarog. MINDANAO, Mumungan, Surigao, Port Banga. PALAWAN, Binaluan. DINAGAT (*Boettcher*).
L. angustus sp. nov.[1]

Körper klein, Halsschild vorn deutlich etwas schämler als die Flügeldecken, Fühler kurz, die vorletzten Glieder stark quer. Halsschild mehr oder minder kräftig punktiert, Flügeldecken nur um ungefähr ein Drittel länger als der Halsschild, um ein Drittel

[1] Vielleicht ist diese Art mit *Lispinus macropterus* Fauvel, den ich nur aus der Beschreibung kenne, identisch. Die Beschreibung stimmt mit einzelnen Stücken des etwas variabeln *angustus* ziemlich überein.

länger als zusammen breit, meist schwach chagriniert und undeutlich punktiert. Länge, 3.5 bis 4.5 mm. LUZON, Los Baños, Mount Maquiling (*Baker*, *Boettcher*), Imugan, Mount Banahao. MINDANAO, Mumungan, Surigao. SIARGAO, Dapa (*Boettcher*).
L. nitidipennis Bernhauer.

Die Art ist ziemlich veränderlich; bisweilen sind die Flügeldecken nur mässig länger als der Halsschild, nur wenig länger als zusammen breit. LUZON, Mount Maquiling (*Baker*).
L. nitidipennis curtipennis var. nov.

Bisweilen ist der Halsschild nur sehr zart punktiert. SIARGAO, Dapa (*Boettcher*)...... *L. nitidipennis tenuipunctus* var. nov.

15. Oberseite nicht oder nur mässig dicht chagriniert, mehr oder minder glänzend .... 16.
Oberseite sehr dicht chagriniert, matt........ 56.

16. Halsschild nicht oder kaum breiter als lang........ 17.
Halsschild viel breiter als lang........ 34.

17. Halsschild mehr oder minder kräftig punktiert........ 18.
Halsschild mehr oder minder fein punktiert........ 31.

18. Halsschild mehr oder minder dicht punktiert........ 20.
Halsschild mehr oder minder weitläufig punktiert........ 19.

19. Flügeldecken um ein Drittel länger als der Halsschild, deutlich chagriniert, Halsschild neben der Mittellinie mit einer dichter punktierten Zone, ausserhalb dieser nur vereinzelt punktiert. Diese Art bildet einen natürlichen Uebergang von den bisher beschriebenen Arten zu den folgenden. Sie ist deutlich, wenn auch nur schwach gewölbt, etwas weniger gestreckt als die vorhergehenden, aber gestreckter als die folgenden Arten. Der Kopf besitzt nur schwache Stirnfurchen und ist sehr fein und mässig weitläufig punktiert. Fühler kurz, die vorletzten Glieder zeimlich stark quer. Halsschild deutlich schmäler als die Flügeldecken, so lang als breit, nach rückwärts ziemlich stark verengt, vor den deutlichen Hinterecken sanft ausgeschweift, in der Mittellinie sehr fein gefurcht, die Punktierung viel stärker als am Kopf, die Seitenfurchen schmal und scharf abgesetzt, bis über die Mitte nach vorn reichend. Flügeldecken um ein Drittel länger als zusammen breit, äusserst fein und spärlich punktiert. Hinterleib ziemlich glänzend, die seitlichen Schrägtriche mässig scharf und weitläufig. Länge, 3.8 mm. LUZON, Balbalan (*Boettcher*). Ein einzelnes Stück.
L. balbalanensis sp. nov.

Flügeldecken nur wenig länger als der Halsschild, auch bei stärkster Lupenvergrösserung ohne Spur einer Chagrinierung, Halsschild bis zum Seitenrande ziemlich gleichmässig punktiert. Eine gewölbte, plumpe Art, stark glänzend. Die Stirnfurchen nur sehr schwach ausgebildet, die Fühler kürzer, die vorletzten Glieder stärker quer, der Halsschild fast breiter als lang, die Punktierung kräftiger, die Seiten nach rückwärts nur wenig verengt, die Seitenfurchen breiter, wenig scharf abgesetzt, viel kürzer, nicht bis zur Mitte nach vorn reichend. Flügeldecken nur wenig länger als zusammen breit, ziemlich kräftig und nicht allzu spärlich punktiert, mit einer deutlichen Subhumeralpunktreihe. Hinterleib überall, auch längs der Mitte deutlich, seitlich gröber und runzelig punktiert, glänzend, ohne

deutliche Seitenschräglinien. Das einzige, bisher bekannte, offenbar unreife Stück ist einfarbig bräunlichrot mit rötlichgelben Beinen. Länge, 3.5 mm. MINDANAO, Port Banga (*Boettcher*).
L. parcus sp. nov.

20. Flügeldecken stärker oder ebenso kräftig als der Halsschild punktiert .... 21.
Flügeldecken viel weniger kräftig als der Halsschild punktiert........ 27.
21. Flügeldecken viel länger als der Halsschild........ 22.
Flügeldecken nicht oder nur wenig länger als der Halsschild........ 26.
22. Flügeldecken kräftiger als der Halsschild punktiert........ 23.
Flügeldecken nicht kräftiger als der Halsschild punktiert........ 24.
23. Grösser, Punktierung dichter und weniger stark, Flügeldecken fast um die Hälfte länger als der Halsschild. Die Art ist durch ihre robuste Gestalt und die kräftige und dichte Punktierung des Halsschildes und der Flügeldecken ausgezeichnet. Von der normalen Färbung, nur sind die Fühler pechschwarz mit bräunlicher Spitze. Kopf ziemlich kräftig und dicht punktiert. Stirneindrücke schwach. Fühler ziemlich kurz, die vorletzten Glieder quer. Halsschild wenig breiter als lang an den Seiten sanft, vollkommen gleichmässig gerundet, in der Mittellinie äusserst fein gefurcht, auf der hinteren Häfte viel stärker und schärfer punktiert als vorn, die Seitenfurchen bis zur Mitte nach vorn reichend, breit und tief ausgebildet. Flügeldecken etwa um ein Viertel länger als zusammen breit, an der Naht und vor dem Hinterrande weitläufiger und weniger stark punktiert als an den Seiten. Hinterleib mässig fein, vorn und an den Seiten stärker punktiert, seitlich mit einer Anzahl schwach ausgebildeten Schrägstrichen besetzt. Länge, 5 mm. LUZON, Mount Polis (*Boettcher*)........ *L. spectabilis* sp. nov.
Kleiner, Punktierung weniger dicht, stärker und schärfer eingestochen. Flügeldecken nur um ein Drittel länger als der Halsschild. Von der vorigen Art überdies in nachfolgendem unterschieden: Der Halsschild ist etwas länger, so lang als breit, die Punktierung mehr gleichmässig, hinten nicht stärker als vorn, die Seitenfurchen länger und schmäler, die Punktierung del Flügeldecken ist fast gleichmässig verteilt, die einzelnen Punkte viel tiefer eingestochen, so dass bei seitlichem Lichteinfall bei jedem Punkt ein weissblinkender Lichtreflex entsteht. LUZON, Haight's Place, Balbalan (*Boettcher*).
L. acutepunctatus sp. nov.
24. Flügeldecken nur wenig oder kaum länger als der Halsschild, weitläufiger punktiert. Länge, 3.2 bis 3.5 mm. LUZON, Los Baños, Mount Maquiling (*Baker*)........ *L. bakeri* Bernhauer.[2]
Flügeldecken um ein Viertel länger als der Halsschild, dichter punktiert .... 25.
25. Punktierung mässig dicht, Fühler kürzer. Gestalt robuster, etwas grösser (4.5 mm), Flügeldecken pechrot. LUZON, Limay, Los Baños (*Baker*)........ *L. picipennis* sp. nov.

[2] Mit dieser Art sehr nahe verwandt ist *Lispinus singaporensis* sp. nov. von Singapore (entdeckt von *Baker*), welche sich durch viel breiteren Kopf, stärkere und dichtere Punktierung des Kopfes, Halsschildes, und der äusseren Seiten der Flügeldecken, weitläufiger punktierte Nahtzone, und etwas grössere Gestalt (Länge, 9 mm) unterscheidet.

Punktierung dichter, Fühler länger. Gestalt schlanker, etwas kleiner (4 mm), Flügeldecken gleich dem übrigen Körper pechschwarz. Ausser vorstehenden Unterschieden, von denen die Dichte der Punktierung wohl am charakteristischesten ist, lässt sich noch in der Bildung des Halsschildes ein weiterer Unterschied feststellen. Dieser ist bei der vorhergehenden Art vor den Hinterecken deutlich etwas ausgeschweift, hier jedoch gleichmässig sanft gerundet. LUZON, Los Baños. MINDANAO, Port Banga (*Boettcher*).

L. punctatellus sp. nov.

26. Tiefschwarz, glänzend, breiter. Fühler schlank und dünn, die vorletzten Glieder länger als breit. Kopf viel schmäler als der Halsschild, ziemlich fein und ziemlich dicht punktiert. Halsschild fast so lang als breit, an den Seiten gleischmässig gerundet, nicht ausgeschweift, in der Mittellinie fein gefurcht, kräftig und ziemlich dicht, ziemlich gleichmässig punktiert, die Seitenfurchen tief und breit, bis zur Mitte nach vorn reichend. Flügeldecken nur wenig länger als der Halsschild, etwas langer als breit, fast so kräftig als dieser, aber viel weitläufiger und ungleichmässig, längs der Mitte jeder Decke spärlich punktiert, die normalen zwei stärkeren Punkte nur wenig oder nicht vortretend. Hinterleib glänzend fein und mässig dicht, längs der Mitte etwas weitläufiger punktiert, die seitlichen Schrägstriche wenig ausgebildet. Länge, 5 mm. PALAWAN, Binaluan (*Boettcher*) .... *L. perniger* sp. nov.[3]

L. parallelopipedus sp. nov.

Rostrot mit dunklerem Hinterleib beträchtlich länger als der Halsschild, weniger glänzend, schmäler, Fühler viel kürzer, die vorletzten Glieder breiter als lang. Der Kopf weniger dicht punktiert. Halsschild weniger kräftig und weniger dicht punktiert, die seitlichen Längsfurchen kürzer und namentlich rückwärts viel breiter und weniger scharf. Flügeldecken weitläufiger und mehr gleichmässig längs der Subhumeralzone stärker punktiert. Die Punktierung des Hinterleibes ist etwas stärker, die seitlichen Schrägstriche deutlicher und schärfer. Länge, 3.5 bis 4.2 mm. LUZON, Paete, Zambales, Mount Banahao, Bayombong, Manila. MINDORO, San Theodoro (*Boettcher*) .... *L. insularum* sp. nov.

Auf Mindanao, Port Banga, und Luzon, Manila, kommt eine Form mit deutlich kürzeren Flügeldecken vor.

27. Flügeldecken mässig, ungefähr ein Viertel länger als der Halsschild .... 28.

Flügeldecken beträchtlich, ungefähr ein Drittel länger als der Halsschild .... 20.

28. Flügeldecken glänzend ohne deutliche Grundskulptur, Körper gewölbter. Tief pechschwarz, Fühler mässig kurz, die vorletzten Glieder nicht oder kaum quer. Kopf mässig fein und mässig dicht punktiert. Halsschild wenig breiter als lang, an den Seiten fast geradlinig,

[3] Mit dieser Art ist nahe verwandt eine Art von den Mollukken, Ternate (Coll. *Dr. Walker*), welche sich durch viel kleinere Gestalt, viel kürzere, gegen die Spitze stark verdickte Fühler, stark quere vorletzte Glieder, weitläufiger Punktierung des Vorderkörpers, kürzere Flügeldecken, und dichtere Punktierung des Hinterleibes unterscheidet. Länge, 4 mm.

L. parallelopipedus sp. nov.

vor den scharfen Hinterecken sehr schwach geschweift, mässig stark und mässig dicht, etwas ungleichmässig punktiert, die Seitenfurchen ziemlich breit und wenig scharf eingegraben. Flügeldecken viel feiner und weitläufiger als der Halsschild, beiderseits der Naht sehr fein, längs der Subhumeralzone stärker punktiert. Hinterleib mässig fein und mässig dicht, längs der Mitte weitläufiger punktiert. Länge, 4 mm. MASBATE, Aroroy. LUZON, Los Baños. LEYTE (*Boettcher*) .... *L. nigerrimus* sp. nov.

Flügeldecken wenig glänzend, deutlich chagriniert, Körper flacher, Färbung weniger dunkel rostrot bis pechbraun. Halsschild seitlich sanft gerundet, Punktierung viel stärker und dichter, Seitenfurchen schmäler, tiefer und schärfer abgesetzt. Flügeldecken kürzer, mässig länger als zusammen breit, die Punktierung etwas stärker und dichter. Hinterleib etwas dichter punktiert. Länge, 3.5 bis 4 mm. MINDANAO, Kolambugan, Surigao. BASILAN (*Boettcher*). *L. opacinus* sp. nov.[4]

29. Halsschild in der Mittellinie stark gekielt ohne Andeutung einer Mittelfurche. Rostgelb (offenbar unreif), mässig stark glänzend. Mit *opacinus* zweifellos nahe verwandt, von ihm durch viel längere, viel feiner und weitläufiger, ungleichmässiger punktierte, weniger deutlich chagrinierte Flügeldecken, kräftiger und dichter punktierten Kopf, weitläufiger und fast stärker punktierten Halsschild, längere Seitenfurchen, und den ungefurchten Mittelkiel des letzteren leicht zu unterscheiden. Länge, 3.6 mm. MINDANAO, Kolambugan (*Boettcher*). Ein einzelnes Stück .... *L. carinicollis* sp. nov.

Halsschild in der Mittellinie sehr fein, aber deutlich erkennbar gefurcht, nicht gekielt. Körper grösser .... 30.

30. Schlanker und kleiner, Flügeldecken sehr fein und weitläufig punktiert. Äusserst fein, schwer sichtbar chagriniert, glänzend. Kopf mässig fein punktiert, Fühler dünn, die vorletzten Glieder nicht quer. Halsschild fast so lang als breit, vor der Mitte am breitesten, stark und ziemlich dicht, ungleichmässig punktiert, die Seitenfurchen scharf und bis über die Mitte nach vorn reichend. Flügeldecken um ein Drittel länger als der Halsschild, ausser der spärlichen, sehr zarten Punktierung mit einer undeutlichen Subhumeralpunktreihe. Hinterleib in der Mitte feiner und weitläufiger punktiert, die seitlichen Schrägstriche lang und deutlich. Länge, 4.5 mm. LUZON, Butac (*Boettcher*) .... *L. butacensis* sp. nov.

Breiter und grösser, Flügeldecken mässig fein und weniger weitläufig punktiert. Von der vorigen Art überdies durch flacheren, stärker und etwas dichter punktierten, nach rückwärts stärker verengten Halsschild, viel stärker und deutlicher chagrinierte Flügeldecken, und stärker und dichter punktierte Subhumeralzone, endlich durch weniger glänzenden, etwas stärker punktierten Hinterleib zu unterscheiden. Länge, 5.5 bis 6 mm. LUZON, Limay (*Boettcher*). *L. puncticollis* sp. nov.

[4] Der Namen *Lispinus opacipennis* Bernhauer, Deutsche Ent. Zeitschr. (1921) 66, muss wegen *Lispinus opacipennis* Bernhauer, Verh. Zool. Bot. Ges. Wein (1915) 96, geändert werden. Ich benenne daher die erstgenannte Art *bolivianus*.

31. Flügeldecken um ein Viertel länger als der Halsschild. Mässig glänzend, sehr fein chagriniert, Kopf fein und wenig dicht punktiert. Fühler ziemlich kurz, die vorletzten Glieder nicht oder schwach quer. Körper ziemlich gewölbt. Halsschild fast so lang als breit, an den Seiten ziemlich gleichmässig, sanft gerundet, vor den rechteckigen Hinterwinkeln schwach ausgeschweift, längs der Mitte äusserst fein gefurcht, mässig fein und mässig dicht punktiert, die Seitenfurchen ziemlich breit, mässig scharf und kaum bis zur Mitte nach vorn reichend. Flügeldecken feiner und weitläufiger als der Halsschild punktiert, die beiden Rückenpunkte deutlich vortretend. Hinterleib fein punktiert, die seitlichen Schrägstriche nicht scharf. Länge, 4.2 bis 5 mm. LUZON, Imugan, Los Baños (*Boettcher*).
L. imuganensis sp. nov.
Flügeldecken nur wenig länger als der Halsschild .... 32.
32. Flügeldecken beträchtlich länger als zusammen breit, ausser den zwei Rückenpunkten kaum sichtbar punktiert, aber mit deutlicher, sehr zarter Chagrinierung, Körper flach, sehr stark glänzend. Kopf ausserordentlich fein und spärlich punktiert, die vorletzten Fühlerglieder ziemlich quer. Halsschild etwas breiter als lang, nach rückwärts etwas verengt, mässig fein und weitläufig punktiert, äussert fein chagriniert, Seitenfurchen breit und nicht scharf abgesetzt. Flügeldecken um ein Viertel länger als zusammen breit. Hinterleib undeutlich punktiert, seitliche Schrägstriche nur schwach angedeutet. Länge, 3.3 mm. MINDANAO, Mumungan (*Boettcher*).
L. mindanaoanus sp. nov.
Flügeldecken nicht oder nur wenig länger als zusammen breit, ohne deutliche Chagrinierung, aber deutlich punktiert. Körper gewölbt, weniger stark glänzend .... 33.
33. Körper grösser und breiter, die Punktierung des Halschildes und der Flügeldecken weitläufiger, die seitlichen Längsfurchen des Halsschildes tiefer und schärfer abgesetzt, Flügeldecken kaum länger als zusammen breit. Hinterleib mit flachen, undeutlich abgesetzten Punkten, seitlich mit feinen, aber immerhin deutlich erkennbaren Schärgstrichen. Länge, 3.8 mm. MASBATE, Aroroy (*Boettcher*). Ein einziges Stück .... *L. parallelicollis* sp. nov.
Körper kleiner und schmäler, die Punktierung des Halsschildes und der Flügeldecken dichter, die seitlichen Halsschildfurchen viel kürzer, flacher und schwächer abgesetzt. Flügeldecken deutlich länger als zusammen breit, Hinterleib mit schärfer abgesetzten Punkten, seitlich kaum mit Andeutung von Schrägstrichen. Länge, 3 mm. LUZON, Zambales (*Boettcher*). Ein einzelnes Exemplar.
L. zambalesanus sp. nov.
34. Halsschild stark glänzend, nicht oder nur äusserst schwach gestrichelt .... 35.
Halsschild bei gewöhnlicher Vergrösserung deutlich gestrichelt, mässig oder wenig glänzend .... 48.
35. Färbung rotgelb bis rostrot .... 36.
Färbung ganz oder grösstenteils pechschwarz bis tiefschwarz .... 38.
36. Hinterleibstergite mit je zwei tiefen Längsfurchen beiderseits der Mitte. Eine zarte, rostgelbe, stark niedergedrückte und stark glän-

zende Art. Kopf nur mässig schmäler als der Halsschild, fein und nur einzeln punktiert. Fühler kurz und dünn, die vorletzten Glieder kaum quer. Halsschild fast um die Hälfte breiter als lang, nach rückwärts ziemlich stark, deutlich etwas ausgeschweift verengt, vor dem Schildchen mit zwei kräftigen Längseindrücken, fein und spärlich punktiert, die seitlichen Längsfurchen tief und scharf. Flügeldecken um ein Drittel länger als der Halsschild, fein und weitläufig punktiert, die beiden Rückenpunkte wenig hervortretend. Hinterleib nur mit einzelnen Punkten an den Seiten, ohne Schrägstriche. Länge, 2.3 bis 2.6 mm. PALAWAN, Binaluan. MINDANAO, Port Banga (*Boettcher*) .... *L. foveiventris* sp. nov.

Hinterleibstergite ohne Längsfurchen jederseits der Mitte, Körper deutlich gewölbt .... 37.

37\. Halsschild und Flügeldecken stark lackglänzend, auch bei schärfster Lupenvergrösserung nicht erkennbar chagriniert, Flügeldecken kräftig punktiert. Rostgelb, Kopf stark und ziemlich dicht punktiert, Fühler kurz, gegen die Spitze verdickt, die vorletzten Glieder stark quer. Halsschild fast un die Hälfte breiter als lang, vor dem Schildchen mit zwei Längseindrücken, kräftig, neben der Mittelinie ziemlich dicht punktiert. Flügeldecken ungefähr ein Viertel länger als der Halsschild, ziemlich kräftig und ziemlich dicht punktiert. Hinterleib deutlich chagriniert, ohne deutliche Punktierung und ohne seitliche Schräglinien. Länge, 2.3 bis 2.5 mm. LUZON, Mount Banahao (*Baker*), Los Baños (*Boettcher*) .... *L. luzonicus* sp. nov.

Halsschild und Flügeldecken weniger glänzend, bei stärkster Lupenvergrösserung deutlich chagriniert, Flügeldecken feiner punktiert. Rostgelb bis rostrot, bisweilen der Kopf und der Hinterleib dunkler. Kopf mässig stark und ziemlich weitläufig punktiert. Auch der Halsschild etwas weitläufiger punktiert, sonst der vorigen Art recht ähnlich. Bei einem Exemplar, welches zugleich kleiner ist, sind die Flügeldecken glänzender. Länge, 2.3 bis 2.7 mm. LUZON, Atimonan, Los Baños, Butac, Manila (*Boettcher*)
L. obsoletipennis sp. nov.

38\. Flügeldecken mässig länger als der Halsschild .... 39.

Flügeldecken viel länger als der Halsschild .... 46.

39\. Halsschild nur mässig breiter als lang, gleichmässig flach, weitläufig punktiert. Von gedrungener breiter Gestalt, pechschwarz, glänzend. Kopf fein punktiert, Fühler gegen die Spitze verdickt, die vorletzten Glieder stark glänzend. Halsschild ohne Längseindrücke vor dem Schildchen, ziemlich fein und mässig weitläufig punktiert, die Seitenfurchen sehr schmal, zeimlich undeutlich, abgesetzt, die Seiten nach rückwärts ziemlich stark verengt. Flügeldecken wenig länger als der Halsschild, ähnlich wie der Halsschild punktiert, wie dieser bei schärfster Lupenvergrösserung undeutlich chagriniert, in der Mitte der Scheibe je mit einem starken Punkt. Hinterleib sehr fein chagriniert, spärlich punktiert ohne seitliche. Schrägstriche. Länge, 4 mm. MINDANAO, Port Banga (*Boettcher*). Ein einziges Stück.
L. planaticollis sp. nov.

Halsschild viel breiter als lang, weniger gleichmässig gewölbt, meist mit zwei Eindrücken, weniger weitläufig punktiert .... 40.

40\. Die Seiten des Halsschildes stark und vollständig gleischmässig gerundet, ohne Ausbuchtung vor den Hinterecken .... 41.

Die Seiten des Halsschildes nach rückwärts stark verengt, vor den Hinterecken mehr oder minder deutlich ausgebuchtet .... 42.

41. Grösser. Pechschwarz mit dunkel rostroten Fühlern, Tastern, und Beinen. Kopf gross, fast so breit als der Halsschild am Vorderrand, stark und dicht, fast etwas runzelig punktiert, dis Stirneindrücke tief und lang. Fühler sehr kurz, gegen die Spitze stark erweitert, die vorletzten Glieder sehr kurz, fast mehr als doppelt so breit als lang. Halsschild in der Mitte stark gerundet erweitert, daselbst so breit als die Flügeldecken, stark quer, um die Hälfte breiter als lang, beiderseits der Mittellinie mit je einem Längseindruck, kräftig und dicht punktiert, die Seitenfurchen tief und über die Mitte nach vorn reichend. Flügeldecken mässig länger als der Halsschild, etwas länger als zusammen breit, fein und spärlich punktiert mit einer deutlich kräftigeren Subhumeralpunktreihe, im Grund äusserst zart chagriniert. Hinterleib kräftig und namentlich gegen die Seiten zu nicht allzuweitläufig, deutlich körnig punktiert, überdies an den Seiten mit etwas erhabenen, sehr feinen Längslinien, nicht schrägstrichen besetzt (ein sehr charakteristisches Merkmal). Länge, 3 mm. LUZON, Los Baños (Boettcher) .... *L. rotundicolis* sp. nov.

Kleiner. Heller pechfarben mit rostgelben Fühlern und Beinen. Kopf schmäler als der Halsschild am Vorderrand, sehr fein und ziemlich weitläufig punktiert, die Fühler weniger gedrungen, die vorletzten Glieder nur um die Hälfte breiter als lang. Halsschild viel feiner punktiert, die Seitenfurchen viel weniger ausgebildet. Flügeldecken stärker und dichter punktiert, ohne Subhumeralpunktreihe. Hinterleib ausser der Chagrinierung nur einzeln punktiert ohne Längslinien an den Seiten. Länge, 2.2 mm. BASILAN (*Boettcher*). Ein einzelnes Stück .... *L. pumilio* sp. nov.

42. Grösser, breiter, die Flügeldecken kürzer, fast nur so lang als der Halsschild .... 43.

Kleiner, schmäler, die Flügeldecken länger, um ein Viertel länger als der Halsschild .... 44.

43. Halsschild vor dem Schildchen kaum gefurcht. Körper stark gewölbt. Kopf ziemlich kräftig und weitläufig punktiert. Fühler gegen die Spitze wenig verdickt, die vorletzten Glieder nur schwach quer. Halsschild so breit als die Flügeldecken, weniger als um ein Drittel breiter als lang, an den Seiten ziemlich stark gerundet erweitert, vor den Hinterecken schwach gebuchtet, am Hinterrand bogenförmig ausgerandet, längs der Mitte mit der normalen abgekürzten feinen Mittelfurche, stärker und dichter als der Kopf, ungleichmässig, neben der Mittelinie dichter punktiert, die Seitenfurchen tief und breit, aber nur mässig scharf abgesetzt. Flügeldecken nur wenig länger als der Halsschild, feiner und viel weitläufiger als dieser, längs der Subhumeralzone etwas stärker und weniger spärlich punktiert, im Grunde ebenso wie der Halsschild bei schärfster Lupenvergrösserung äusserst zart chagriniert. Hinterleib deutlich chagriniert, einzeln punktiert, ohne Schräg- oder Längslinien. Länge, etwas über 3 mm. LUZON, Mount Polis (*Boettcher*). Ein einziges Stück .... *L. montanellus* sp. nov.

Halsschild vor dem Schildchen mit zwei zeimlich entwickelten Längseindrücken. Körper weniger gewölbt. Kopf viel feiner und weitläufiger punktiert. Fühler kürzer, die vorletzten Glieder stär-

ker quer. Halsschild nach rückwärts zeimlich stark und viel ausgeschweifter verengt, längs der Mittelinie nicht gefurcht, kielförmig erhoben, feiner und in den Längseindrücken dichter punktiert. Seitenfurchen breiter, mehr gegen den Seitenrand verschoben und schwächer entwickelt. Flügeldecken fast noch kürzer als bei der vorigen Art, viel feiner und spärlicher, längs der Schulterzone kaum deutlicher punktiert, wie der Halsschild auch bei schärfster Lupenvergrösserung ohne erkennbare Chagrinierung. Hinterleib weniger dicht chagriniert, stärker und weniger spärlich punktiert. Länge, 2.8 mm. LUZON, Manila (*Boettcher*). Ein einzelnes Stück.
L. manilensis sp. nov.

44. Flügeldecken und Halsschild kräftig punktiert.. 45.
Fiügeldecken und Halsschild äusserst fein und spärlich punktiert. Eine kleine, wenig gewölbte, sehr fein punktierte Art ohne sichtbare Chagrinierung des Vorderkörpers. Pechrot, der Hinterleib dunkler, die Beine rötlichgelb. Fühler gedrungen, die vorletzten Glieder ziemlich stark quer. Halsschild gut um ein Viertel breiter als lang, vor dem Schildchen mit zwei grösseren, quergestellten Punkten, an den Seiten vor der Mitte ebenfalls mit je einem starken Punkt, die übrige feine Punktierung sehr spärlich und ungleichmässig angeordnet, die seitlichen Längsfurchen ziemlich undeutlich. Flügeldecken ungefähr ein Viertel länger als der Halsschild, ziemlich undeutlich und spärlich punktiert. Hinterleib deutlich chagriniert mit einigen wenigen, deutlichen Punkten. Länge, 2.5 mm. SIARGAO, Dapa (*Boettcher*). Ein einziges Stück............ *L. laevicollis* sp. nov.

45. Halsschild gleichmässig schwach gewölbt, ohne Doppeleindruck vor dem Schildchen, ziemlich dicht punktiert. Pechschwarz bis pechbraun mit rostgelben Beinen. Kopf sehr fein punktiert, vorletzte Fühlerglieder schwach quer. Halsschild um ein Viertel breiter als lang, an den Seiten flachbogig gerundet, vor den Hinterecken nur undeutlich geschweift, stärker als der Kopf und viel dichter punktiert, Mittelfurche sehr fein, die Seitenfurchen auf einen schwachen rundlichen oder länglichen Eindruck reduziert. Flügeldecken fast um ein Viertel länger als der Halsschild (dadurch einen deutlichen Uebergang zur nächsten Gruppe bildend), ähnlich wie der Halsschild punktiert, bei schärfster Lupenvergrösserung äusserst fein, aber immerhin erkennbar chagriniert. Hinterleib namentlich an den Seiten deutlich flach punktiert. Länge, 3 bis 3.2 mm. SURIGAO, Dapa (*Boettcher*).
L. aequicollis sp. nov.

Halsschild mit zwei deutlichen Längseindrücken vor dem Schildchen, mässig dicht punktiert. Die Basis der Flügeldecken in der Regel gelblich (bei einzelnen, anscheinend zu dieser Art gehörigen Stücken ist jedoch die Basis kaum heller). Kopf grob punktiert, die vorletzten Fühlerglieder stark quer. Halsschild um ein Drittel breiter als lang, ebenso stark als der Kopf, ungleichmässig punktiert, die Seitenfurchen deutlich, ziemlich lang. Flügeldecken nur mässig als der Halsschild, wenig dicht, aber ziemlich scharf eingestochen punktiert, stark glänzend, unter schärfster Lupenvergrösserung äusserst schwach chagriniert. Hinterleib dicht chagriniert, gegen die Seiten mit einzelnen

Punkten. Diese Art ist dem *specularis* Bernhauer sehr ähnlich, unterscheidet sich jedoch leicht durch die kürzeren, stärker und dichter punktierten Flügeldecken. Länge, 2.5 mm. LUZON, Mount Maquiling (*Baker*), Los Baños (*Boettcher*)..................*L. basipennis* sp. nov.

46. Halsschild mässig kräftig punktiert. Körper kleiner, mässig gewölbt. Kopf mässig kräftig, weitläufig punktiert, Fühler wenig gegen die Spitze verdickt, mässig quer. Halsschild um ein Viertel breiter als lang, nach rückwärts sanft ausgeschweift verengt, nicht sehr stark und weitläufig punktiert, vor dem Schildchen mit zwei dichter punktierten Längseindrücken, die Seitenfurchen ziemlich stark eingegraben, ziemlich lang. Flügeldecken um ein gutes Drittel länger als der Halsschild, bei stärkster Lupenvergrösserung wie dieser mit einer zart angedeuteten Grundskulptur, mässig stark und mässig dicht punktiert. Länge, 2.8 mm. LUZON, Laguna (*Boettcher*). *L. lagunae* sp. nov.

Halsschild kräftig punktiert, Körper grösser und stark gewölbt...... 47.

47. Körper grösser, Halsschild ziemlich grob und mässig dicht punktiert. Tiefschwarz mit rostbraunen Fühlern und rostgelben Beinen. Kopf kräftig punktiert, Fühler gegen die Spitze deutlich erweitert, die vorletzten Glieder schwach quer. Halsschild um ein Viertel breiter als lang, nach rückwärts ziemlich stark deutlich ausgeschweift verengt, vor der Mitte am breitesten, vor dem Schildchen mit zwei flachen Eindrücken, ungleichmässig, vorn gegen die Seiten zu spärlich und fein, in den seitlichen, ziemlich stärker aber nicht scharf abgesetzten, breiten Eindrücken kräftig und dicht punktiert, bei schärfster Lupenvergrösserung mit kaum wahrnehmbarer Grundskulptur. Flügeldecken fast um die Hälfte länger als der Halsschild. länger als zusammen breit, fast so kräftig wie der Halsschild, ziemlich gleichmässig und mässig dicht punktiert, mit äusserst schwacher Grundskulptur. Hinterleib cylindrisch, deutlich chagriniert, mit weniger Punkten an den Seiten. Länge, 3.5 bis 4 mm. LUZON, Mount Polis, Butac, Haight's Place, Laguna (*Boettcher*).... *L. praenobilis* sp. nov.

Körper kleiner, Halsschild sehr grob und ziemlich dicht punktiert. Dor vorigen Art sehr nahe verwandt, ausserdem durch mehr rötliche Färbung des Vorderkörpers, viel gröbere und dichtere Punktierung des Kopfes, dünnere Fühler, viel kürzeren Halsschild, stärker ausgeschweifte Seiten, viel schmälere und schärfer abgesetzte Seitenfurchen, kürzere, viel kräftiger und dichter punktierte Flügeldecken verschieden. Der Halsschild ist um ein Drittel breiter als lang, die Flügeldecken nur um ein Drittel länger als der Halsschild. Länge, 3.2 bis 3.4 mm. LUZON, Balbalan (*Boettcher*)..*L. vulneratus* sp. nov.

48. Flügeldecken mindestens seitlich mehr oder minder kräftig punktiert .... 49.

Flügeldecken sehr fein punktiert (vergleiche auch *impressicollis* unter 51) .... 52.

49. Flügeldecken viel länger als der Halsschild, Körper mehr oder weniger flach .... 50.

Flügeldecken nur mässig länger als der Halsschild, Körper weniger flach .... 51.

50. Halsschild und Flügeldecken pechschwarz bis tiefschwarz, Flügeldecken etwas mehr als um ein Drittel länger als der Halsschild, viel länger als zusammen breit, kräftiger und schärfer eingestochen punktiert, so dass bei seitlicher Ansicht ein weissblinkender Lichtschein sichtbar ist. Länge, 3 mm. LUZON, Benguet, Haight's Place (*Boettcher*). .... *L. acutepunctatus* sp. nov.

Bei einer grösseren Reihe von Exemplaren sind die Punkte auf den Flügeldecken etwas feiner und weitläufiger, weniger scharf, der Körper etwas flacher, die Flügeldecken etwas kürzer, nur mässig länger als zusammen breit. Da mir Übergangsstücke vorzuliegen scheinen, stelle ich diese stücke vorläufig zu vorstehender Art. Länge, 2.5 bis 2.8 mm. LUZON, Trinidad, Balbalan, Mount Polis, Mount Banahao, Imugan .... *L. acutipunctatus* var. *pennatus* var. nov.

Halsschild und Flügeldecken rostrot bis rostgelb, der übrige Körper meist etwas dunkler, selten der ganze Vorderkörper rostbraun, niemals jedoch schwarz. Ausser durch die Färbung von der vorigen Art durch kleinere Gestalt, kürzere Flügeldecken, und viel feinere und weitläufigere Punktierung des Vorderkörpers verschieden. Länge, 2 bis 2.3 mm. LUZON, Mount Banahao, Los Baños, Laguna, Imugan. POLLILO. MINDORO, San Theodoro. MINDANAO, Surigao, Port Banga (*Boettcher*). Die dunklere Form hielt ich ursprünglich für eine eigene Art (*brunneorufus*), bei genauer Ansicht konnte ich jedoch keine grundlegenden Unterschiede feststellen. *L. opaculus* sp. nov.

51. Halsschild und Flügeldecken wenig matt, ziemlich stark glänzend, ziemlich kräftig, scharf und ziemlich dicht punktiert, braunrot, Kopf und Hinterleib meist dunkler, Körper kleiner, schlanker, weniger gewölbt. Länge, 2.5 mm. LUZON, Butac, Limay, Laguna, Manila, Los Baños .... *L. subnitens* sp. nov.[5]

Halsschild und Flügeldecken wenig glänzend, sehr deutlich chagriniert. Körper breiter, stärker gewölbt. Länge, 2.8 bis 3.6 mm. *L. impressicollis* Motschulsky.

Diese Art ist eine äusserst veränderliche. In Grösse und Färbung, Gestalt des Halsschildes, Länge der Flügeldecken, und in der Stärke und Dichte der Punktierung insbesondere der Flügeldecken variiert die Art so bedeutend, dass es vorläufig nicht möglich ist, festzustellen, ob eine oder die andere Form vielleicht als selbstständige Art zu betrachten sein wird. Die auffallendsten Formen lassen sich in folgender Tabelle auseinander halten:

a. Flügeldecken kraftig punktiert .... *b*.
Flügeldecken fein punktiert .... *e*.

[5] Dieser Art nahe verwandt ist eine Art aus Sumatra, welche sich durch grössere Gestalt, viel stärkeren Glanz des Körpers, stärkere und dichtere Punktierung des Halsschildes und der Flügeldecken und bedeutendere Länge der letzteren, endlich durch dunkle Färbung des ganzen Körpers unterscheidet. Länge, 3.2 mm. Si Rambe, XII. 1890 bis III. 1891 (*E. Modigliani*). Im Museum zu Genua und in meiner Sammlung. *Lispinus subnitidus* sp. nov.

b. Flügeldecken mässig kräftig und nicht dicht punktiert ....*c.*
Flügeldecken kräftig und dicht punktiert...............*d.*

c. Kleiner, weniger breit, die Eindrücke am Halsschild stärker, Punktierung stärker. Länge, 3.2 bis 3.5 mm. Ostindien: (Hongkong, Kobe, Singapore); Ceylon (Kandy); Sumatra (Karang, Medan); Borneo (Sandakan); Nias-Inseln. Philippinen: Palawan (Binaluan), Luzon (Manila).... Stammform.
Bisweilen viel stärker chagriniert, matter. PALAWAN, Binaluan.
L. impressicollis subsp. *binaluanensis* nov.
Grösser, breiter, die Eindrücke am Halsschild erloschen, Punktierung feiner. Länge, 3.5 mm. Deutsch Ostafrika, Usaromo (*Methner*).
L. impressicollis subsp. *africanus* nov.

d. Halsschild und Flügeldecken dichter punktiert, matter. Engaño, Malaconni (*Modigliani*). Ein Stück von Palawan (Binaluan) scheint mir zu dieser Unterart zu gehören.
L. impressicollis subsp. *enganoensis* nov.
Halsschild und Flügeldecken weniger dicht punktiert, wenig matt. Japan, Formosa.
L. impressicollis subsp. *longulus* Sharp.

e. Halsschild ziemlich glänzend, sehr weitläufig punktiert, Flügeldecken matt chagriniert. MINDANAO, Mumungan (*Boettcher*).
L. impressicollis subsp. *sublaevicollis* nov.
Halsschild und Flügeldecken mehr oder minder matt chagriniert ....*f.*

f. Halsschild breiter order mindestens so breit als die Flügeldecken, herzförmig, vor den Hinterecken stark ausgeschweift. LUZON, Los Baños, Mount Banahao, Mount Maquiling, Lamao, Mount Isarog, Zambales, Limay. MASBATE, Aroroy. PALAWAN, Binaluan. MINDANAO, Mumungan (*Baker, Boettcher*). BORNEO (*Thaxter*). Seychellen (*Sladen*).
L. impressicollis subsp. *robusticollis* nov.
Halsschild meist deutlich schmäler als die Flügeldecken, kaum oder nur schwach vor den Hinterecken ausgeschweift. LUZON, Los Baños, Mount Maquiling. LEYTE, Burauen. BASILAN, Dinagat. MINDANAO, Kolambugan. SIARGAO, Dapa (*Baker, Boettcher*). Comoren (Voeltzkow). Madagaskar. Diese und die vorhergehende Unterart zeigt bei zahlreichen Stücken irisierenden Schimmer am Kopf und Halsschild.
L. impressicollis subsp. *sub tilipennis* nov.

52. Halsschild gleichmässig schwach gewölbt, vor dem Schildchen ohne Spur von Längseindrücken, gleichmässig, ziemlich dicht punktiert.

Rotbraun mit helleren Flügeldecken. Kopf fein und ziemlich dicht punktiert. Fühler kurz, die vorletzten Glieder ziemlich stark quer. Halsschild stark quer, vor den Hinterecken schwach gebuchtet, ziemlich stark glänzend, im Grunde bei starker Vergrösserung deutlich gestrichelt. Flügeldecken fast um ein Drittel länger als der Halsschild, sehr fei und weitläufig punktiert, im Grunde zart gestrichelt. Länge, fast 3 mm. PALAWAN, Binaluan. Ein einziges Stück.

L. collaris sp. nov.

Chagrinierung dichter, Flügeldecken kürzer, Körper kleiner. Länge, 2.5 mm. PALAWAN, Binaluan. *L. collaris* subsp. *complanus* nov.

Halsschild vor dem Schildchen mindestens mit schwacher Andeutung von zwei Längseindrücken .... 53.

53. Flügeldecken vollständig matt, Halsschild deutlich glänzend. Rostgelb, die Wurzel der Hinterleibsringe dunkler, Beine rötlichgelb. Den *Lispinus opaculus* mihi recht ähnlich, von ihm durch die matt chagrinierten, schwächer punktierten Flügeldecken, breiteren und weniger glänzenden Halsschild, und breiteren Körper verschieden. Länge, 2.3 mm. PALAWAN, Binaluan. Ein einzelness Stück.

L. alutipennis sp. nov.

Flügeldecken mindestens schwach glänzend .... 54.

54. Flügeldecken etwas weniger fein punktiert,[6] Flügeldecken beträchtlich länger als der Halsschild. Körper grösser. Länge, 2.3 bis 2.5 mm. Selangor. MINDORO, San Theodoro, Subaan. LUZON, Limay, Zambales. CATANDUANES, Vivac. PALAWAN, Binaluan. LEYTE, Burauen. MINDANAO, Port Banga, Mumungan, Kolambugan. Basilan. DINAGAT. Eine sehr veränderliche Art in Färbung, Punktierung, Länge der Flügeldecken, und Halsschildeindrücke.

L. rubidus Cameron.

Flügeldecken sehr fein oder erloschen punktiert........ 55.

55. Flügeldecken mässig länger als der Halsschild. Länge, 2 mm. LUZON, Los Baños. MINDANAO, Kolambugan (*Baker*).

L. fulvus Motschulsky.[7]

Flügeldecken viel länger als der Halsschild. Gelbrot mit helleren Flügeldecken und Beinen, glänzend, flach. Kopf sehr fein und weitläufig punktiert. Fühler kurz, die vorletzten Glieder stark quer. Halsschild beträchtlich breiter als lang, nach rückwärts sanft ausgeschweift verengt, vor der Basis mit zwei Längseindrücken und in diesen mit je einem starken Punkt, beiderseits der Mittellinie mässig fein und ziemlich dicht, sonst spärlich und sehr fein punktiert. Die Seitenfurchen sind wenig stark entwickelt. Die Grundskulptur ist sehr fein, aber deutlich sichtbar. Flügeldecken fast um ein Drittel

[6] Hierher auch die fein punktierten Formen des *impressicollis* Motschulsky, welche sich von *rubidus* durch grössere, breitere Gestalt und deutlichere Chagrinierung unterscheidet.

[7] Ob die vorliegenden Stücke mit *fulvus* Motschulsky wirklich identisch sind, ist mir nicht vollkommen zweifellos, da ich typische Stücke bisher nicht zu Gesicht bekam.

länger als der Halsschild, äusserst fein und weitläufig punktiert, überdies äusserst fein gestrichelt. Hinterleib ziemlich glänzend mit vereinzelten Punkten. Länge, 2 mm. Philippinen, St. Michael (*Boettcher*), 27. März, 1926, in Pilzen erbeutet.

L. boleticola sp. nov.

56. Flügeldecken um die Hälfte länger als der Hallsschild .... 57.
    Flügeldecken höchstens um ein Viertel länger als der Halsschild.... 58.
57. Flügeldecken ausser der matten Chagrinierung ziemlich kräftig punktiert, Körper grösser, die Tergite jederseits mit zwei kurzen Längsfurchen. Schwarz, matt, Fühler, Taster, und Beine rötlichgelb. Kopf mässig fein und weitläufig punktiert, die Punkte am Scheitel in zwei kurzen Längsreihen angeordnet, Fühler mässig kurz, die vorletzten Glieder kaum quer. Halsschild wenig schmäler als die Flügeldecken, um ein Drittel breiter als lang, nach rückwärts deutlich etwas ausgeschweift verengt, vor der Basis mit zwei Längseindrücken, mässig stark und mässig dicht punktiert, die Seitenfurchen tief und scharf eingegraben. Flügeldecken in der Subhumeralzone dichter punktiert. Hinterleib matt chagriniert, ausser den oben erwähnten Längsfurchen an den Seiten mit einigen kräftigen Punkten. Länge, 3 mm. LUZON, Haight's Place. Ein einziges Stück.
    L. abdominalis sp. nov.
    Flügeldecken ausser der matten Chagrinierung kaum punktiert, Körper kleiner, die Tergite ohne Längsfurchen. Von der vorigen Art ausserdem noch durch einfarbig gelbrote Färbung, weitläufigere, am Scheitel unregelmässige Punktierung des Kopfes, viel flachere Gestalt des Halsschildes und der Flügeldecken, weitläufiger punktierten, vor den Hinterecken kaum ausgeschweiften Halsschild und stärkere Basaleindrücke des letzteren verschieden. Uberdies ist die Chagrinierung der Flügeldecken nicht, wie bei *abdominalis* längsgestrichelt, sondern lederartig gewirkt. Länge, 2.5 mm. LUZON, Laguna (*Boettcher*) .... *L. rugosipennis* sp. nov.
58. Körper grösser, gewolbt, Habitus von *impressicollis* Motschulsky.... 59.
    Körper kleiner, flachgedrückt .... 62.
59. Halsschild dicht, fast gleichmässig punktiert. Pechrot bis pechbraun, die Punktierung des Kopfes, Halsschildes, und der Flügeldecken ist kräftig und dicht. Die Fühler sind kurz, die vorletzten Glieder stark quer. Halsschild stark quer, vor den Hinterecken stark ausgeschweift, vor dem Schildchen mit zwei Längseindrücken, die Seitenfurchen breit, nicht scharf abgesetzt. Flügeldecken um ein Viertel länger als der Halsschild, wenig länger als breit. Hinterleib ausser der Chagrinierung weitläufig und kräftig punktiert. Länge, 3 mm. PALAWAN, Binaluan (*Boettcher*).... *L. punctithorax* sp. nov.
    Halsschild mässig dicht, ungleichmässig punktiert............................ 60.
60. Flügeldecken kaum länger als der Halsschild, Körper breiter. Kopf breit, nur wenig schmäler als der Halsschild. Pechschwarz mit helleren Fühlern und Beinen. Kopf mässig fein und weitläufig punktiert, vorletzte Fühlerglieder quer. Halsschild mässig stark

und weitläufig punktiert, von der Gestalt des vorigen mit zwei schwachen Basaleindrücken, jederseits der Mitte mit zwei stärkeren in einer Längsreihe stehenden Punkten von denen der vordere etwas weiter nach aussen gerückt erscheint. Flügeldecken ausser der matten Chagrinierung nur mit einigen wenigen, mässig kräftigen ungleichen Punkten. Hinterleib weitläufig punktiert, matt chagriniert. Länge, 3 mm. BORNEO, Sandakan (*Baker*).
L. curtipennis sp. nov.

Flügeldecken wesentlich länger als der Halsschild. Kopf viel schmäler als der Halsschild .... 61.

61. Flügeldecken mässig länger als der Halsschild, Körper breiter, pechschwarz, Kopf dichter punktiert, Halsschild flacher, mit tieferen Eindrücken, kräftiger und dichter punktiert, Flügeldecken zusammen kaum kürzer als lang, kräftiger, Hinterleib an den Seiten feiner punktiert. Länge, 2.8 mm. PALAWAN, Binaluan. Ein einziges Stuck .... *L. quadratipennis* sp. nov.

Flügeldecken viel länger als der Halsschild, Körper weniger breit, tiefschwarz, Kopf weitläufiger punktiert, Halsschild gewölbter mit flacheren Eindrücken, weniger kräftig und weniger dicht punktiert, Flügeldecken zusammen viel kürzer als lang, feiner, Hinterleib an den Seiten kräftiger punktiert. Länge, 3.2 mm. (*Lispinus curticollis* Bernhauer nec Fauvel.) .... *L. tristis* nom. nov.

Von *Lispinus curticollis* Fauvel unterscheidet sich die Art durch viel grössere Gestalt, viel längere Flügeldecken, stärkere Punktierung, und die matt chagrinierte Oberseite auf den ersten Blick.

62. Halsschild und Flügeldecken grob chagriniert, letztere stärker punktiert, Körper grösser, ganz flachgedrückt. Länge, 2.5 mm. MINDANAO, Mumungan. LUZON, Bangui. Sonst in Birma, Tenasserim, Java, Sarawak, Engano, Nias-Inseln aufgefunden.
L. coriaceus Fauvel.

Halsschild und Flügeldecken weniger grob chagriniert, letztere fein oder erloschen punktiert. Körper kleiner, weniger flachgedrückt 63.

63. Körper breiter, weniger fein punktiert, viel matter, Flügeldecken kaum länger als zusammen breit. Länge, 1.8 bis 2.2 mm. SIARGAO, Dapa. PALAWAN, Binaluan. MINDANAO, Port Banga, Mumungan. BASILAN. LEYTE. Sonst von Ceylon, Indien, und den Nias-Inseln bekannt .... *L. subopacus* Kraatz.

Körper viel schmäler, deutlich etwas glänzend, feiner, die Flügeldecken fast erloschen punktiert. Flügeldecken um ein Viertel länger als zusammen breit. Länge, 2.2 mm (bei ausgezogenem Hinterleib). MINDORO, San Theodoro. Ein einziges Exemplar.
L. brevipennis sp. nov.

NACHBEMERKUNG

Das Ergebnis meiner vorstehenden Arbeit ist die Erkenntnis dass wir es in *Lispinus* vielleicht mit der schwierigsten Staphylinidengattung zu tun haben. Die Unterschiede sind zum grossen Teil nur relative die nur durch ein entsprechendes Vergleichsmaterial gefunden werden können. Bei vielen Arten ist eine

grosse Variabilität vorhanden, welche das Erkennen der Art sehr erschweren. Bezüglich der philippinischen Arten war glücklicher Weise ein so reichhaltiges Material vorhanden, dass es mir gelungen ist, eine Sonderung der Arten vorzunehmen. Trotzdem ist es immerhin leicht möglich, dass sich bei Hervorkommen weiteren Materiales eine oder die andere Art als identisch herausstellen oder bisher als eine Art betrachtete Stücke als verschiedenen Arten zugehörig zu bezeichnen sein werden. Jedenfalls ist es sicher, dass die Gattung eine ausserordentlich artenreiche ist und dass die Arten oft nur durch sehr schwache Merkmale von einander zu trennen sind, die nur bei schärfster Aufmerksamkeit gefunden werden können.

240788

CONCRETIONS IN WATER-LAID TUFF IN THE PHILIPPINE ISLANDS

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University of the Philippines, Manila

FOUR PLATES

Water-laid volcanic tuff is found extensively in southwestern Luzon, and Manila suburbs occupying the higher areas are underlain with it. During the latter part of 1925 in the course of road construction in the San Francisco del Monte Subdivision, one of the suburbs of Manila, Mr. H. H. Buch found balls of rock material about the size of coconuts, and these were described in local newspapers as fossil coconuts. Members of the division of geology and mines of the Bureau of Science made several trips to the locality, and the specimens collected by them were entrusted to the author for examination. The balls are not fossil coconuts, but ordinary concretions. Similar concretions were also found in a road cut between Balaoan and Bacnotan, in La Union Province, northern Luzon. Their mode of formation has presented a very interesting study.

The concretions found in water-laid tuff are masses of inorganic matter, sometimes arranged in concentric layers and sometimes almost structureless. The shape is prevailingly round like a ball, and the size varies from that of a pea to that of a large coconut. The inside color grades from dark brown to reddish brown with the presence of concentric layers alternating in color from dark brown to gray. These concretionary masses are generally harder than the inclosing matrix.

The concretions are found from 1 to 2 meters below the surface. In most cases they are formed above the permanent ground-water table. During the rainy season, however, when the ground-water table is raised nearly to the surface, these concretions are well below the water table. The descending meteoric water, which is more or less highly charged with mineral substances leached from the overlying soil, is free to circulate in the formation. This yearly process is probably re-

sponsible for the formation of the concretions and the concentric structure.

The volcanic tuff where these concretions are found is stratified, and the successive beds are varyingly fine-grained with some pumiceous material. The tuff has not been indurated but has been consolidated through cementation. It is rather homogeneous in character and is usually porous, so that ground water is free to move.

Apparently, there is no nucleus in most of the concretions but, theoretically, all concretions are formed around a nucleus, whether it be an organic or an inorganic substance, and the shape of a concretion is directly influenced by the shape and form of the nucleus.

The formation in which these concretions are found shows no fossils, either plant or animal. In the absence of fossils and any traceable carbonaceous matter, it may be safely assumed that, in most cases, the nuclei of the concretions must have been small pieces of inorganic matter, and when growth and cementation took place, a rounded form was the result.

The growth and development of these concretions invite some consideration of the possible physico-chemical processes involved. On the basis of the character of the matrix, the more or less homogeneous material furnishes conditions in which the resistance met by the growing concretions is nearly uniform. It is also conceivable that so long as the resistance offered by the surrounding matrix does not exceed the strength of growing crystals of the different minerals forming within the individual concretions the form will be rounded or will have a spheroidal symmetry.

The concentricity of the layers of these concretions is likely due to the chemical action of underground water. The nucleus serving as the center of solution or subtraction of the more-soluble part of the matrix, which is constantly being carried away by ground water, also serves as a center of cementation and deposition of the least-soluble materials carried by ground water, which are deposited in replacement of the dissolved substances. In other words, solution and deposition or cementation take place at the same time.

Examination of the concentric layers, reveals that they are made up of several thin layers, sometimes singly and sometimes bunched together to form a thicker layer. Such a structure can be explained only by the alternating dry and wet seasons of the region. Each single thin layer represents one seasonal cycle or

the equivalent of one year's time. These concentric layers seem to show that during the time of their formation, the Philippine Islands were already enjoying a climate similar to our present-day climate.

In order to discover further the relations of the concretions to the inclosing tuff formation a chemical analysis was made of the concentric layers and of the matrix.

TABLE 1.—*Analyses of concretions and tuff (matrix) from the San Francisco del Monte Subdivision, Rizal Province, Luzon, Philippine Islands.*[a]

Substance.	Tuff (matrix).	Concretions.
	Per cent.	*Per cent.*
Calcium oxide (CaO)	5.18	6.35
Magnesium oxide (MgO)	4.15	4.35
Aluminum oxide (Al_2O_3)	18.47	19.93
Ferric oxide (Fe_2O_3)	3.93	4.28
Manganese dioxide (MnO_2)	0.77	4.32
Manganous oxide (MnO)	0.05	0.43
Silicon dioxide (SiO_2)	58.10	50.38
Sulphur trioxide (SO_3)	0.46	0.41
Carbon dioxide (CO_2)	0.04	1.75
Water (H_2O)	7.39	6.61
Sodium chloride + potassium chloride ($NaCl + KCl$)	1.12	1.22
Total	99.66	100.03

[a] Analyses made by Miss Lourdes Ocampo, of the Bureau of Science, Manila.

The most noticeable feature of the analyses is the loss of about 7.72 per cent of silica from the matrix. The concretions, on the other hand, show a gain of about 3.55 per cent of manganese oxide, 1.71 per cent of carbon dioxide, 1.46 per cent of aluminum oxide, and 1.17 per cent of calcium oxide. The increase of manganese and carbon dioxide points to the formation of manganese dioxide and calcium carbonates. These substances, mostly, brought by the ground water, serve as the cementing material of the tuff in the formation of concretions. The increase of aluminum oxide probably shows that the ferro-magnesian minerals and the feldspar,when disintegrated and leached out by the percolating waters, left behind the less-soluble aluminum compounds.

The silica of the tuff is partly dissolved by the percolating waters highly charged with carbon dioxide. In its place manganese dioxide is deposited from the sulphate in the presence of alkaline waters. The alkalinity of the water was probably due to the disintegration of feldspathic minerals.

The following reactions may roughly represent what has taken place in the formation of concretions in the San Francisco del Monte Subdivision, Rizal Province, Luzon:

$$MnCO_3 + H_2SO_4 \rightarrow MnSO_4 + H_2CO_3.$$
$$MnSO_4 + CaCO_3 + O_2 \rightarrow CaSO_4 + MnO_2 + CO_2.$$ [1]
$$CO_2 + 2H_2O + SiO_2 \rightarrow H_2SiO_3 + H_2CO_3.$$
$$CO_2 + 3H_2O + SiO_2 \rightarrow H_4SiO_4 + H_2CO_3.$$

The facts that the concretions are found in the finer-grained member of the tuff formation and that protrusions are found in some of the concretions, as shown in some of the pictures, seem to suggest that they were formed after the deposition of the tuff; and, therefore, are of epigenetic origin. There is little doubt that these concretions were formed by the work of underground waters, possibly helped by descending meteoric waters highly charged with carbon dioxide.

One may picture the region during the Pliocene time as only slightly above sea level. Ponds of various sizes were present, and sluggish streams brought the finer sediments into such shallow basins. Later the region slowly emerged, and then the work of underground water and descending meteoric waters began to form the concretions. Later in the period or probably during the early Pleistocene there was further emergence accompanied by minor faulting and slight folding.

The drops of mud mentioned by Edward Otis Hovey,[2] and referred to by Wallace E. Pratt,[3] were in the opinion of the writer entirely different from the concretions described in this paper.

Some of the mud balls mentioned by Pratt displayed concentric structure and in the opinion of the writer were concretions formed in situ by the work of underground water. It is not postulated, however, that all mud balls found and mentioned by Pratt are formed by the work of underground water. A distinction of volcanic ejecta from concretions of sedimentary origin is hereby suggested. It is common knowledge that concretions of epigenetic or even syngenetic origin have a different chemical composition from the inclosing matrix, and the inner structure is invariably concentric, while volcanic ejecta and mud drops should have the same chemical composition as the matrix.

It is difficult to conceive how a mud drop, which is formed in the air and rotates as it falls to the ground, should have a con-

[1] Dunnington, F. P., Am. Journ. Sci. III 36 (1888) 177.
[2] Am. Journ. Sci. 14 (1902) 343.
[3] Journ. Geology 24 (1916) 450–455.

centric structure. It is also difficult to conceive how a falling body, which is gaining momentum and is accelarated in its journey downward and is growing by accretion, should have preference for some materials over others. Again it is difficult to understand how a mud ball 8 or 10 inches in diameter could stay in the air long enough to grow to the size of a man's head and at the same time retain its spheroidal shape, even granting that it falls in water. It is conceivable, however, that the nucleus of the concretions are the mud drops of Pratt, but their growth and formation seem to be due to the work of underground water.

The increase in the amount of calcium carbonate and manganese dioxide seems to show that these compounds play the rôle of cementing material in the formation of concretions.

The absence of any recognizable ancient craters in the immediate neighborhood of the concretion deposit mention in this paper is another reason against the ejecta theory of the formation of these concretions.

SUMMARY

Concretions in water-laid tuff were discovered in the bedded volcanic tuff formation in San Francisco del Monte, a suburb near Manila. Similar concretions are found in a road cut between Balaoan and Bacnotan, La Union Province, Luzon.

The concretions are epigenetic in origin and are generally rounded or spherical with concentric layers. Megascopically some of them have no apparent nucleus.

ILLUSTRATIONS

PLATE 1

FIG. 1. Small round concretions, some of them with a few protrusions.
2. A small concretion, showing no visible nucleus and hardly any concentric layers; *a*, exterior; *b*, cut surface.

PLATE 2

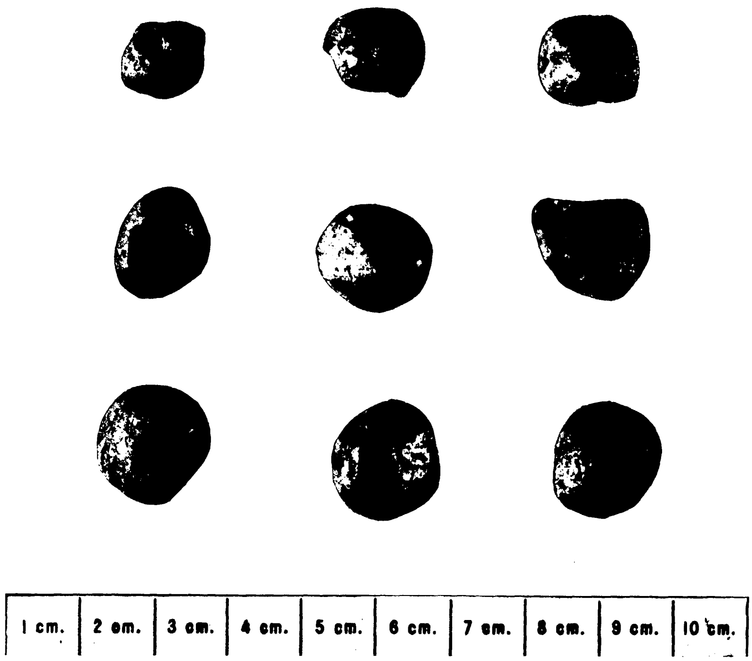
FIG. 1. A medium-sized concretion; exterior.
2. The concretion shown in fig. 1; cross section, showing a nucleus and concentric layers around the nucleus.

PLATE 3

FIG. 1. A large concretion; outside view, showing stratifications, *s*.
2. A large concretion; cross section, showing concentric layers broken through by later replacement.

PLATE 4

FIG. 1. A large concretion; cross section, showing the influence of the shape of the nucleus, *N*, on the early development; also, the interference of less-soluble material, *X*, in later growth.
2. An elongated concretion, showing the nucleus, the concentric layers, and some stratifications that are part of the concentric layers around the nucleus.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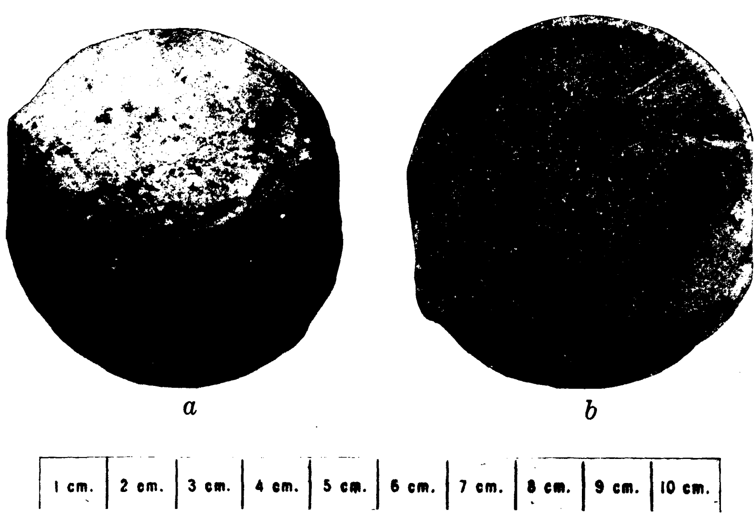
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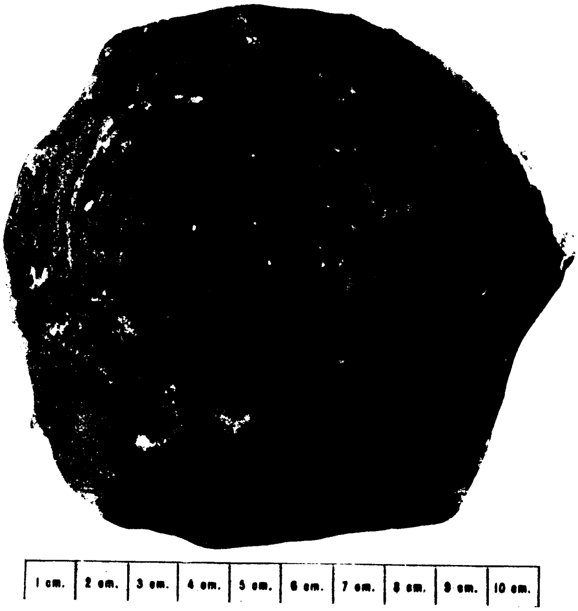
PLATE 1.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1 cm. 2 cm. 3 cm. 4 cm. 5 cm. 6 cm. 7 cm. 8 cm. 9 cm. 10 cm.

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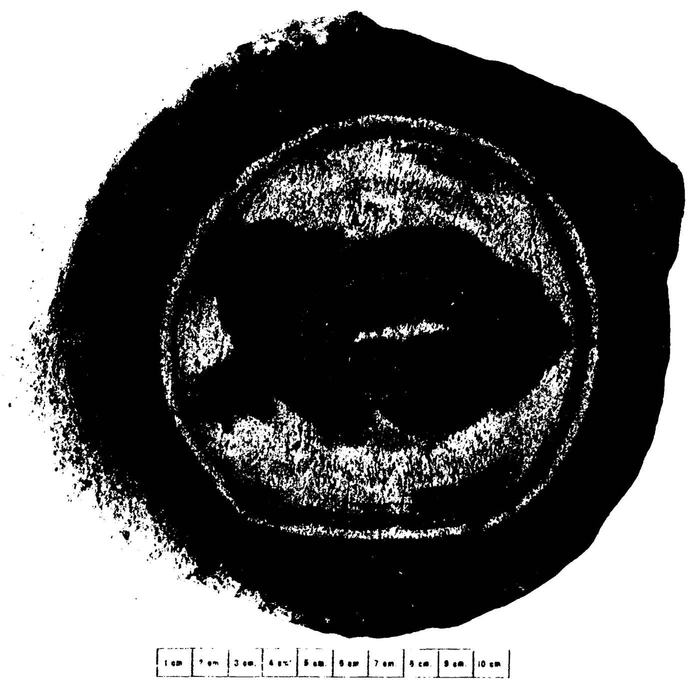
PLATE 2.

1



2

PLATE 3.

1

2

PLATE 4.

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COGON AND RICE STRAW AS RAW MATERIAL FOR PAPER MANUFACTURE

By F. D. REYES and A. O. CRUZ

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INTRODUCTION

It is generally believed that the Philippine Islands contain an abundant supply of raw materials for the manufacture of paper. Indeed, the public forests contain a vast amount of standing timber. Wide areas of public and private lands are overgrown with cogon, talahib, and bamboo of various species. However, an adequate supply of fibrous material is only one of the several items required in the production of the finished paper. Fuel, caustic soda, and bleaching, sizing, and coloring materials have to be imported. The fibrous material must not only be available in large quantities and at low cost, but it must also yield a pulp suitable in quality and amount with the least expenditure of chemicals and energy.

The Philippine public forests contain several species of wood that previous experiments in this laboratory [1] showed to be suitable for the production of the mechanical pulp that is largely used in the manufacture of newsprint. The desirable species are widely scattered in the forest, and there is no known area of sufficient extent where these species predominate. There is, of course, the possibility of planting sufficiently large areas with the species that experiments have shown to be suitable for conversion into mechanical pulp. This would take a long time, and

[1] Philip. Journ. Sci. § A 2 (1907) 81–89.

until it is done, there appears to be no prospect for the establishment of a paper factory.

The desirability of establishing a paper factory in the Philippines is unquestionable. So far, however, no serious attempt has been made to manufacture paper in the Islands. This may be due to the uncertainty attached to every new business venture or to lack of capital. For economical production the capacity of the paper factory should be at least 10 tons of paper per day, which would require an investment of about three-fourths of a million pesos. The Philippine Government has tried to encourage the establishment of new industries by guaranteeing a small profit on the investment. However, no one has taken advantage of the Government's help because the returns on capital invested are much greater in established business enterprises. It seems, therefore, that a more substantial inducement should be offered to capital desiring to invest in new Philippine industries.

COGON GRASS

Cogon grass grows wild in many parts of the Islands on public as well as on private lands. It is a hardy plant and very difficult to eradicate. The provinces that have good means of communication with Manila and contain large areas of cogon are Rizal, Pampanga, Tarlac, Pangasinan, and Nueva Ecija. With the increase in population the area of cogon will gradually diminish, because more land will be taken up for agricultural purposes. However, the cogon area is so large that the grass will be available for many years to come. The cogon fields are usually burned during the dry season, either purposely or accidentally, thus cleaning the fields and promoting new growth. Domestic animals do not eat the mature cogon, but relish the young cogon.

The period of growth of cogon begins with the first rains in May, and during the rainy months of June, July, August, and September the growth is very rapid. Towards the close of the rainy season in October and November the growth is slower. With the advent of the dry season in December or January, the growth is practically arrested and the grass gradually dries up as the dry season advances.

An investigation was undertaken to estimate the yield of cogon per unit area and the changes in the cellulose content during the period of growth. A rolling field covered with cogon

in Alabang, Rizal Province, Luzon, was selected for the experiment. The land is considered by the farmers in the neighborhood to be of medium fertility. Plots measuring 1 by 10 meters were marked out, and the grass was cut at various periods during its growth. The cut grass was immediately weighed in the field and then taken to the laboratory for analysis. The method of analysis used was that recommended by Cross and Bevan. The yield of cogon is given in Table 1 and the chemical analyses in Table 2.

TABLE 1.—*Yield of cogon grass on measured plots at Alabang, Luzon.*

Lot No.	Date cut.	Yield of lot.	Moisture loss on air drying.	Total moisture content.	Yield of cogon grass per hectare.		Average height of cogon.
					Freshly cut.	Oven dried 100°-105° C.	
		kg.	*Per cent.*	*Per cent.*	*Metric tons.*	*Metric tons.*	*cm.*
1	Aug. 24, 1927	18.5	57.0	60.7	18.5	7.3	116
2	Sept. 28, 1927	22.4	55.2	58.6	22.4	9.3	136
3	Oct. 26, 1927	22.0	48.5	51.9	22.0	10.6	143
4	Nov. 23, 1927	26.5	46.7	51.2	26.5	12.9	160
5	Dec. 23, 1927	25.0	42.5	47.2	25.0	13.2	165
6	Jan. 6, 1928	23.5	31.4	36.5	23.5	14.9	163

TABLE 2.—*Analyses of air-dried cogon grass from plots at Alabang, Rizal.*

Lot No.	Date cut.	Moisture.	Aqueous extract.	Fats and waxes.	Ash.	Total cellulose.	Pectose bodies by difference.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Aug. 24, 1927	8.64	6.20	1.92	4.49	44.84	33.91
2	Sept. 28, 1927	7.53	7.23	1.42	4.75	46.55	32.52
3	Oct. 26, 1927	6.65	8.19	1.27	5.65	46.99	31.25
4	Nov. 23, 1927	8.46	7.37	1.13	6.72	45.18	31.14
5	Dec. 23, 1927	8.28	6.75	1.13	6.72	45.35	31.77
6	Jan. 23, 1928	7.14	6.15	1.22	6.20	46.74	32.55

It will be seen from Table 1 that the yield of fresh cogon increases from 18.5 metric tons per hectare in August to 26.5 metric tons toward the close of the rainy season in November. From December the cogon gradually assumes a dryer appearance because of a decrease in the water content. However, the yield of dry cogon per hectare increases with age. The analyses recorded in Table 2 show that air-dried cogon has approximately 8 per cent of moisture. Computed on the dry basis the ash has a

TABLE 3.—*Digestion and bleaching test of cogon and rice straw.*

Material used.	Caustic soda (100 per cent) per 100 parts of sun-dried material.	Yield of pulp oven-dried per 100 parts of oven-dried material.	Weight of beaten pulp (oven-dried).	Strength of bleaching solution. Per cent available chlorine.	Total available chlorine in solution.	Excess of chlorine.	Bleaching powder (30 per cent available chlorine) consumed per 100 parts of oven-dried pulp.	Loss of pulp in bleaching per 100 parts of oven-dried pulp.	Hours of bleaching.
			g.		g.	g.	g.		
Cogon	20	31	8.916	0.50	0.4686	0.00142	17	11	25
			8.916	0.94	0.9372	0.33758	22	9	1
Do	15	35	9.785	0.50	0.6600	None	22	12	25
			9.785	0.94	0.9000	0.00920	30	7	2
Do	12	36.2	8.914	0.50	0.9372	Traces	35	9	25
			8.914	0.94	1.8744	0.49640	51	14	2
Do	10	37.4	9.815	0.44	1.2496	Traces	42	17	23
			9.815	0.94	1.8744	0.18080	57	18	2
Rice straw	4	46.9	[a] 11.606	0.49	0.6090	0.009	17	9	25
			11.606	0.92	1.2180	0.2059	29	9	2
Do	8	45.9	9.712	0.50	0.5991	0.0953	17	7	1.5
			9.712	1.00	1.1982	0.1411	36	11	1.5

[a] Bleached pulp is brownish.

marked tendency to increase with maturity. On the other hand, the cellulose content does not seem to be greatly affected by the age of the grass.

Cogon is preferably cut during the dry season; at that time the rice farmers have completed their field work and are available for harvesting the grass. Then, too, if cogon is cut during the rainy season it is liable to rot on the field. Transportation is generally difficult during the rainy season.

Careful inquiry among farmers as to the probable cost of cogon indicates that air-dried cogon in bulk or in bales can be delivered in Manila at from 20 to 25 pesos per metric ton.

Digestions of cogon with varying amounts of caustic soda to determine the yield of pulp and the quantity of bleaching powder required to bleach to standard color were carried out. The process is as follows:

Two hundred fifty grams of cogon cut into pieces 7 to 10 centimeters in length were taken for each digestion. The weighed sodium hydroxide was dissolved in 1,650 cubic centimeters of water, which was found sufficient to cover the grass. The digestion was carried out at from 160 to 165° C. for a period of three hours. When the digester had sufficiently cooled, the contents were placed on a 50-mesh screen and thoroughly washed until the wash water was no longer colored. The pulp was then beaten in a porcelain or iron mortar, washed, and dried in the oven.

For bleaching the pulp about 8 to 10 grams of oven-dried pulp were soaked in a definite quantity of water and repulped in a beaker. The bleaching-powder solution was then added. The excess of chlorine was determined by titration with sodium thiosulphate. The pulp, bleached to standard color, was washed thoroughly and dried in the oven to constant weight. The results obtained are given in Table 3.

The tensile strength of handmade cogon paper, sized with starch and tested in strips 2 inches wide and 2 inches between clamps in a Schopper paper-testing machine, is given in Table 4.

The possibility of using cogon for the manufacture of cardboard was also determined. For this purpose the grass was digested with lower percentages of caustic soda and also with lime. The digestion was carried on at 160 to 165° for three hours using 500 grams of cogon and 3,300 cubic centimeters of the digesting solution. The results show that 4 per cent of caustic soda (100 per cent pure) was the minimum amount that

could be used to produce a pulp suitable for cardboard production, and that the yield amounts to 51.5 parts of oven-dried pulp per 100 weight of oven-dried cogon. Digested with 12.7 per cent quick lime, the resulting pulp was incompletely digested and difficult to beat. To produce a pulp similar to that produced by 4 per cent caustic soda requires 25 per cent of lime. The market price of caustic soda is 150 pesos per ton, and of lime 40 pesos per ton. At these prices it will be seen that it is much cheaper to use caustic soda than lime. Table 5 shows the relative ease of reducing cogon and rice straw into pulp for the manufacture of cardboard when digested with caustic soda and with lime.

TABLE 4.—*Tensile strength of handmade cogon paper.*

[Two-inch strips and 2 inches between clumps.]

No. of test.	Thickness.	Tensile strength.
	mm.	*kg.*
1	0.100	7.8
2	0.091	9.0
3	0.080	6.4
4	0.080	7.1
5	0.090	9.1
6	0.095	8.3
7	0.080	7.6
8	0.085	6.6
9	0.088	7.7
10	0.085	6.8
Average	0.087	7.6

TABLE 5.—*Digestion of cogon and rice straw with soda and lime.*

Material.	Caustic soda (100 per cent) used per 100 parts of air-dried material.	Oven-dried pulp obtained per 100 parts of oven-dried material.	Lime (100 per cent) per 100 parts of air-dried material.	Oven-dried pulp obtained per 100 parts of oven-dried material.
Cogon	4	51.5	12.7	64.0
Rice straw	2	55.4	12.7	56.7
Do	4	46.9	6.1	58.4

RICE STRAW

Rice is grown throughout the Philippine Islands and is the principal food of the people. The provinces of central Luzon in which the rice plant is extensively cultivated, are considered

the granary of the Philippines. The principal rice-producing provinces are Bulacan, Pampanga, Tarlac, Pangasinan, and Nueva Ecija. These provinces are crossed by railroads leading to Manila. Motor transportation between Manila and these provinces is highly developed through a system of good public roads. The navigable Pampanga River drains Bulacan, Pampanga, and Nueva Ecija Provinces.

It is customary in these provinces to harvest the rice plant including the straw. The harvested plant is exposed to the sun in order to dry the grain. After drying, the grain is separated from the straw either by hand, by animal power, or by means of threshing machines. The rice straw is usually left on the ground to rot and serves as a fertilizer to increase the humous content of the soil. A part of the straw is sometimes used for feeding work animals, but the greater part is wasted. However, in the districts near Manila, the rice straw is sent to Manila in bulk, where it finds a ready sale as bedding for work animals and to some extent as feed for carabaos.

The rice grown in central Luzon is usually shipped to Manila by rail, although motor-truck transportation is becoming more important particularly in the nearby provinces. At present, rice straw is usually shipped to Manila in bulk by means of river boats or is loaded on bamboo rafts and floated down the river. Rice straw is sold in Manila in bales at 2.5 centavos per kilogram. A dealer in rice straw assured one of us that he finds no difficulty in purchasing as much as 3,000 to 4,000 tons of rice straw in one season from Bulacan Province alone at from 1.5 to 2 centavos per kilogram delivered in his warehouse in Tondo alongside the river. A lower price is paid during the harvest time and for two or three months thereafter. Later in the season a higher price is demanded. The fact is that the supply of rice straw is very much greater than the demand.

In Table 6 are given the area planted to rice, the yield of grain, and the estimated yield of straw.[2]

Possibly one-half to two-thirds of the amount of straw produced by the five provinces named in Table 6 is not easily available for commercial use, due either to the great distances from the shipping point or to the difficult means of transportation. Rice grown within a reasonable distance of rivers and canals, highways and railroad lines is available for pulp and paper manufacture.

[2] From the annual report of the Bureau of Agriculture for 1925.

TABLE 6.—*The area planted to rice, the yield of grain, and the estimated yield of straw in five provinces of central Luzon.*

Province.	Area planted.	Yield of grain.	Estimated rice straw produced.	Tons of straw per hectare.
	Hectares.	*Metric tons.*	*Metric tons.*	*Tons.*
Bulacan	58,900	74,200	123,000	2.1
Pampanga	71,110	79,400	138,000	1.9
Nueva Ecija	177,710	314,000	515,000	2.9
Tarlac	80,120	81,200	136,000	1.7
Pangasinan	195,890	309,000	509,000	2.6
Total	583,730	857,800	1,421,000	[a] 2.24

[a] Average per hectare.

A portable bailing machine could go with the threshing machine to bale the straw produced by the latter. The total expense in bailing rice straw does not exceed 3 centavos per bale of 40 kilograms. The farmer could thus get an additional income from the sale of the straw.

Assuming that only one-tenth of the rice straw produced is available for paper manufacture, Bulacan Province alone is able to supply a 10-ton paper mill. The staple food of the inhabitants being rice, it is reasonable to expect that as the population increases, more rice will be planted and consequently more straw will be available for paper manufacture.

Rice straw is used in Japan and other rice-producing countries as a raw material for paper and cardboard manufacture. The demand in Japan is limited only by the supply.

The analysis of a sample of rice straw from Bulacan Province is given in Table 7.

TABLE 7.—*Rice straw from Bulacan Province.*

	Per cent.
Moisture	9.84
Ash	15.23
Fats and waxes	1.86
Cellulose	37.84
Aqueous extract	13.66
Pectose bodies	21.57
Total	100.00

The most striking difference between the analysis of rice straw and of cogon grass is the quantity of ash and cellulose. Rice straw has two and one-half times as much ash as cogon, whereas

the cellulose content based on the dried materials is only about 42 per cent for rice straw against 50 per cent for cogon.

Digestion experiments were made with rice straw using the same procedure as that used for cogon, with the exception that instead of 1,650 cubic centimeters of solution the volume used was 2,000 cubic centimeters. The results obtained are given in Table 3.

The strength of handmade rice-straw paper sized with starch and tested in strips 2 inches wide and 2 inches between clamps is given in Table 8.

TABLE 8.—*Tensile strength of rice-straw paper.*

[Two-inch strips and 2 inches between clumps.]

No.	Thickness.	Tensile strength.
	mm.	*kg.*
1	0.08 9	8.1
2	0.081	5.7
3	0.088	7.2
4	0.108	7.7
5	0.105	9.3
6	0.091	5.9
7	0.077	6.3
8	0.077	6.0
9	0.090	6.1
10	0.091	5.9
Average	0.090	6.8

RICE STRAW FOR CARDBOARD MANUFACTURE

In Table 5 it is shown that rice straw digested with 2 per cent caustic soda produces a pulp suitable for cardboard and easier to beat than cogon pulp obtained with 4 per cent caustic soda. Using 12.7 per cent lime the resulting rice-straw pulp is of the same quality as that produced by using 2 per cent caustic soda. Lower quantities of lime (6.1 per cent) may be used, but the resulting pulp is rather difficult to beat.

CONCLUSIONS

1. Cogon grass and rice straw are available in commercial quantities for the manufacture of paper. Cogon has to be especially cut and dried for this purpose. As the years go by the easily accessible land will be devoted to agriculture with the result that the available cogon fields will be found farther and

farther away from the means of transportation. Cogon fields of medium fertility may be expected to yield about 12 to 16 tons of air-dried grass per hectare.

2. Rice straw, on the other hand, does not have to be cut as it is a waste by-product in threshing the rice plant. The central Luzon rice provinces; namely, Bulacan, Pampanga, Nueva Ecija, Tarlac, and Pangasinan, are estimated to produce 1,421,000 tons of straw averaging about 2.4 tons of rice straw per hectare. Most of the straw produced at present is wasted. Bulacan Province alone is able to supply a 10-ton paper mill with rice straw.

3. Rice straw requires for digestion about one-third as much caustic soda as cogon and is easier to bleach. In the Philippines where chemicals are expensive this is considered a great advantage.

4. Cogon has 50 per cent cellulose and rice straw 42 per cent based on the dry material. Due, however, to the fact that rice straw requires a milder treatment than cogon the yield of pulp from rice straw is about 15 per cent greater than the yield from cogon.

5. Paper made from cogon is stronger than that made from rice straw.

THE FERN GENUS PLAGIOGYRIA

By Edwin Bingham Copeland

Of the University of California, Berkeley

FIFTEEN PLATES

Genus PLAGIOGYRIA Mettenius

The original generic diagnosis [1] reads as follows:

Sori partem nervorum superiorem, paullulum ac sensim incrassatam, occupantes, distincti vel denique parenchyma nervis interjectam occupantes et confluentes, exindusiati, margine revoluto attenuato obtecti, margine denique explanato denudati. Sporangia pedicellata, helicogyrata, annulo completo obliquo instructa, rima transversali inter cellulas stomii dehiscentia. Sporae tetraëdrico-globosae vel trilobae.

Foliorum petiolus trunco continuus ac basi incrassata persistens, lamina profunde pinnatipartita vel pinnatisecta, difformis; sterilium segmenta serrata, nervis Sub-Taeniopteridis vel Eupteridis dentes intrantibus, liberis; fertilium segmenta angustiora, margine attenuato integra vel lacera, nervis sensim ac paullulum incrassatis, marginem attenuatum non intrantibus, liberis vel arcu intramarginali confluentibus.

A genus of cyatheoid ferns, terrestrial, characterized by short (not arborescent) erect or suberect caudices; the bases of the stipes enlarged, flat on the inner face, and with a strong median ridge on the outer face of each, dividing this face into two surfaces each of which, in most species, bears a row of excrescences construed as aërophores; the stipe containing a single vascular bundle, which expands or divides in the enlarged base; fronds of moderate size, simply pinnate or deeply pinnatifid, dimorphous; veins free, except as the tips of soriferous veinlets may unite; sori submarginal, borne on the swollen forks of once-forked veinlets but becoming confluent, protected while immature by the scarious reflexed margin of the pinna; sporangium with an oblique annulus forming a complete ring.

Plagiogyria is perhaps the most natural—that is, isolated and clearly definable—of all the genera included in recent years in Polypodiaceæ. As usually happens when the nature of such a

[1] Ueber einige Farngattungen. II. Plagiogyria, Abhandl. Senkenberg. naturf. Gesells. 2 (1858) 275.

group is not recognized (compare *Davallodes, Taenitis, Leptochilus, Christiopteris*), different authors have placed these ferns in a variety of unrelated groups. Mettenius and Kuhn included them in Cyatheaceæ. Hooker could see no sufficient ground for generic separation from *Lomaria*, in which the first species were described. Diels and Christensen placed them in the Pterideæ.

In a rearrangement of the genera, on which a general publication is expected to ensue, I place *Plagiogyria* coördinate with *Cyathea*, both in Polypodiaceæ, but lower on the phylogenetic trunk than *Onoclea, Diacalpe, Dryopteris,* and *Athyrium*. Bower [2] gives it substantially the same position, but raises it to family rank, constituting a new family, Plagiogyriaceæ. On rather important grounds of convenience, I do not follow him in this.

The question of general policy involved here was clear a decade ago, and I may as well quote.[3]

> Independent of *Cyathea* and its relatives, and of the Matoniaceae and their descendants, we have in the Polypodiaceae several clear-cut series of descendants of *Dennstaedtia*, or of ancient ferns now best represented by *Dennstaedtia*. These series cross the old tribal lines of the Polypodiaceae, sometimes with but little regard for them. The old artificial tribes, the Aspidieae, Asplenieae, Davallieae, Pterideae, and Vittarieae and Polypodieae, not to speak of the Acrosticheae as a tribe in the older sense, have, therefore, to be recast or abandoned. As to the family conception, it seems to me clear that *Dryopteris*, and even *Athyrium*, as well as *Peranema, Diacalpe, Monachosorum* and *Acrophorus*, and probably all of the Woodsieae, must fall in one family with *Cyathea;* while the descendants of *Dennstaedtia*, including possibly the Polypodieae [4] and Vittarieae,[4] and certainly all of the real Davallieae [5] and Pterideae, form another family; and while the descendants of the Matoniaceae fall in that family [Matoniaceae]—or else we must include in the Polypodiaceae, as completely as we know how to do so, the nearest common ancestry of all of these distinct phylogenetic lines. If we adopt the former alternative, the definition of the resulting families by diagnosis will become a pure impossibility. There seems to me, therefore, no alternative but to include Cyatheae, Matoniaceae and Polypodiaceae in one family, retaining, for the resulting great family, the name by which the overwhelmingly largest part of it is already known.

If, as Bower suggests, we have other genera descended from *Plagiogyria*, or from ferns nearer to it than to any other survivers, the number of ill-defined families that will result from the consistent use of his policy is an open question. Even if,

[2] Ferns 2 (1926) 275.

[3] Sarawak Mus. Journ. 2 (1917) 292, 293.

[4] I now regard these groups, properly construed, as matoniid.

[5] I am now satisfied that *Davallia* itself is not dennstaedtiid.

as is my present belief, *Plagiogyria* is without descendents or "nephews," and is unrelated to any ferns with interrupted annulus except through other ferns with oblique annulus, still I am indisposed to give it family rank; for, although easy enough to recognize and to define, such a family would be far less isolated than any group now recognized by most botanists as a family of Filices—with the sole exception, probably, of Parkeriaceæ, which we may be treating as a family because of what we do not know about *Ceratopteris* fully as much as because of what we do know.

While *Plagiogyria* as a genus dates back only to 1859, and only five species were then known, the distinctness of the group, as shown by one or another character, was recognized earlier. Kunze [6] invented the name for the group, but left it as a subgenus of *Lomaria*. Presl [7] suggested a genus to be recognized by the nature of the vascular bundle in the stipe, and Wallich [8] had already described the enlarged stipe bases.

The anatomical peculiarities of *Plagiogyria* have been studied so well by Mettenius, and more recently by Bower,[9] that I have been content, in most instances, with verifying their findings.

Mettenius, as to *P. semicordata,* and after him Diels, describes the vascular bundle of the stipe as divided into three while it traverses the enlarged base. Bower agrees as to the species named; but in *P. pycnophylla* he finds that, instead of dividing, it becomes very wide and thin, with the middle part displaced squarely outward. This is what happens in the most or all of the Oriental species.

Mettenius construed the aërophores, or pneumatophores, as correlated with the development of hard, impervious, mechanical tissues, providing for the aëration of the living parenchyma in spite of the hard shells which inclose the latter. Bower believes that the aërophores function chiefly while the fronds are still very young, providing for their aëration through an external protective layer of gummy or gelatinous material. Both may be right, but I find more evidence to support Mettenius. The aërophores vary in development with that of the hard and impervious tissues that are construed as making them necessary. *Plagiogyria christii* is less hard and woody than are most Orien-

[6] Bot. Zeit. 7 (1850) 867.
[7] Epim. Bot. (1849) 156.
[8] Quoted by Hooker, Spec. Fil. 3: 21.
[9] Ann. Bot. 24 (1910) 423; Ferns 2 (1926) 275.

tal species, and the aërophores are so feebly developed that they were missed, although looked for, when the species was described. *Plagiogyria petelotii* has very slender bases, with only one or two evident aërophores on each side. *Plagiogyria tuberculata* has the hardest sclerenchyma shells known in the genus, and may have a full dozen distinct excrescences on each side, in two rows or somewhat irregularly placed. It likewise bears them, where there is no other suggestion of pinnæ, on the upper part of the stipe.

When these excrescences are produced on the rachis, they are immediately adjacent to the insertion of the pinnæ. If alternating with the pinnæ of very young fronds, as described and figured by Bower (p. 277), they might possibly still be adjacent to the attachment of the pinnæ after the frond is expanded; but I have not been able to see, in very young fronds of *P. pycnophylla* or of any other species, either that they are so placed or that they precede the other structures in development to the extent that Bower depicts.

Mettenius describes and figures a marginal veinlet connecting the tips of the fertile veinlets of *P. scandens,* but of no other species. His *P. scandens* is understood to be *P. pycnophylla.* No such marginal strand could be found in Bower's material of this species or in mine.

It does not seem to have occurred to Mettenius or to Bower to give any biologic explanation of the dimorphous fronds or the acrostichoid fructification of *Plagiogyria,* perhaps because so many other ferns have also these features. These and the scarious margin of the fertile frond are paralleled in a number of distinct phylogenetic lines, but are none the less interesting for that reason, in the biologic understanding of *Plagiogyria.*

Dimorphism and acrostichoid fructification do not always go together. *Elaphoglossum* and *Acrostichum* (as to the pinnæ) are acrostichoid without much contraction of the fertile frond, and the contraction is not extreme in *Egenolfia.* Some species of *Cyathea,* and more of *Phymatodes,* have moderately dimorphous fronds and definite sori; and *Tectaridium* has extremely dimorphous fronds but retains its indusia. Still, the instances in which loss of area and indefinite fructification are associated far outnumber those in which one of these features is found without the other; *Osmunda* (*cinnamomea*), *Stenosemia, Polybotrya, Psomiocarpa, Hemigramma, Stenochlaena, Christiopteris, Cheiropleuria, Platycerium, Leptochilus, Loma-*

gramma, most species of *Campium,* and *Merinthosorus* (as to the pinnæ) should be a long enough list to make this clear. For additional similar examples, it may be noted that in *Aglaomorpha, Photinopteris* and *Thayeria* (as to the pinnæ), in *Drymoglossum,* and notably in certain species of *Loxogramme,* contraction of lamina is associated with expansion of the sori, without their yet becoming fully acrostichoid. The joint evolution of a pair of characters in a score of distinct evolutionary lines is proof enough of their causal connection.

Plagiogyria belongs in this list. In most species the fertile pinnæ are just wide enough to bear a good belt of sporangia on each side of the costa; and in the American species, though the contraction is usually less extreme, it extends to the essential loss of sterile lamina by these fronds. Mettenius noted the comparative restriction of the sporangia to the veinlets of *P. glauca,* and their spread to the "parenchyma" of the other species he knew. In this respect, *P. pycnophylla* is like *P. glauca,* and *P. euphlebia* is somewhat so. In all species the sporangia are most congested on the veinlets; and in no species, even those just named, are they so confined to the veinlets as to prevent their crowding all of the available surface as they mature.

If the significance of the acrostichoid evolution (for this feature is never primitive; in the most of the groups named, the descent from known ancestors with definite sori and uniform fronds is already clear) were in the production of more sporangia, the contraction of the lamina would seem to defeat or curtail this accomplishment. The fact is that there are several elements in this evolution.[10] The one advantage always attained, and attained in association with the contraction of the frond, is not in the production but in the dissemination of the spores. My belief is that the available material is the usual limiting factor on the production of spores, and that no advantage is to be gained by ferns in general by an increase in the fruiting area. There is of course a premium on the protection of sporangia and spores; ferns care for this by a considerable variety of protective "devices." A problem at least equally general seems to be dissemination; for their most numerous and conspicuous peculiarities are to be interpreted as special devices to accomplish this.

The back of the normal frond, where the sporangia are borne by the ancestors of every genus listed in this connection, unless

[10] See my paper on comparative ecology of the Polypodiaceæ, Philip. Journ. Sci. § C 2 (1907) 1–74, 4 pls.

it be *Osmunda,* seems to be a satisfactory place for their production; but not nearly so good for the scattering of the spores. Aside from the fact that the body of the frond is in the way of their free discharge into the air, its back is a damp place—must be a damp place for the plant's vegetable welfare, but the spores must be discharged into dry air, if, in general, they are to have any good chance of wide dispersal. This is so absolutely necessary that the mechanism of the annulus has been evolved to discharge them when the air is dry, and only then. The contraction of the fertile frond gets rid of the area of leaf that obstructs dispersal and guards a supply of humid air beneath itself. Also, not having to guard against desiccation as the vegetative frond must do, the specialized fertile frond can be located specifically where the chance of being dry is greatest. Thus, the fertile pinnæ of practically every genus and species, bearing dimorphous pinnæ on the same frond, are borne at the apex. Thus, the fertile part of the simple frond of *Hymenolepis* is a very contracted apical segment. Thus, in *Plagiogyria,* as is the general rule when the whole frond is differentiated, the fertile frond has a much longer stipe than does the sterile. The sterile fronds are exposed to light, and to the danger of the wind, just as far as the selective ancestral experience has proven to be safe. The fertile fronds are carried beyond this point, exposing the mature sporangia to conditions of dryness which may not be chanced by the vegetative frond. As the vegetative leaf could not be expected to endure and function, if exposed as are the fertile fronds, the vegetative structures and area of the latter are done away with. With the loss in area the acrostichoid stand of the sori is too obviously correlated to require further discussion.

The scarious margin is sometimes called a false indusium. Similar structures are found in many of the genera regarded as relatives of *Pteris,* in many species of *Vittaria,* in *Hymenolepis platyrhynchos,* and in *Oreogrammitis.* They may be expected to perform the function of indusia better than indusia can. This function is protection of the sporangia and spores while protection is needed. While the sporangia are immature, this cover is folded tightly over them. When they, or a part of them, are mature, and the spores are ready to be scattered, the cover rises—or rather sinks—away from them, and swings outward, and finally upward, giving the bed or line of sporangia free

exposure to the air. Because these false indusia are more massive and complicated in structure than are real indusia, their movement can be, and is, hygroscopic, and reversible. Exposed to desiccation, they so move as to expose the sporangia to the same influence. Wet again, they perform the reverse movement, folding back more or less tightly over the fruiting surface. Even in old herbarium specimens this motility is not wholly lost. If a frond with the sporangia exposed be soaked for study, the sporangia may then be found securely covered.

The structural peculiarities of *Plagiogyria* would pass as evidence of considerable geologic age, but its geographic distribution is that of a comparatively new genus. The appreciable number of local species, and the focusing of these, in China and Borneo, are indications of recent evolutionary activity; that is, *Plagiogyria* is not another *Sequoia* or *Matonia*. My belief is that it is a fern of approximately Chinese origin, and that its present distribution marks the spread it has been able to make. There are more species in China than anywhere else. Every species of at all wide Oriental distribution is found there, and in whatever direction a line of possible fern migration is followed, the number of species grows less, and the genus presently disappears. The presence of eight species in Borneo offers the only considerable exception to the regularity of this thinning out with distance from China. This is due to two pairs of local species; of these four, three have been collected once each, and the remaining one twice. As a real element of the fern flora, the place of *Plagiogyria* in Borneo is probably not much more prominent than its position with regard to China would make probable. The report of eight species from the Philippines merely expresses the more thorough exploration and study there. Of these eight, one (*P. nana*) is of questionable status; one (*P. christii*) is very close to a Chinese species; and one (*P. falcata*) is very local. Elsewhere in the Orient, between Java and Japan, such a local species, however well marked, is likely to await future detection.

To the west, all of the four most wide-spread species reach to the Himalayas, but none is known in peninsular India. To the south, three of the same four reach Java. Toward the southeast, only a single species is known to reach Celebes, though the typically Malayan fern flora blankets Celebes and New Guinea without a break. Beyond Celebes there is a report of *P. euphle-*

bia in New Guinea; but I mistrust it, because this species is not otherwise known to approach New Guinea, and I have received under this name a New Guinea fern of another genus.

Still farther, *P. euphlebia* is regularly cited from Queensland. It is an eloquent testimonial to the service of Hooker and Baker to pteridology that this error has remained current and unquestioned for fifty years. Ferdinand Müller [11] described a new species, *Lomaria articulata,* with pinnæ articulate to the rachis, so loosely jointed that, as Bailey's "lithogram" shows,[12] the frond falls apart in drying. Because of resemblance in the form of the pinnæ, Müller carefully and, one would have supposed, sufficiently distinguished it from *Lomaria euphlebia,* in his original publication. But this did not deter Baker [13] from combining the two, nor Bailey, Diels, Christensen, nor Hayata from perpetuating Baker's error. I have never seen the fern, but I do not believe that Müller could see paleæ where there were none; and am sure that any fern with "*stipite . . . basin versus . . . squamis brunneo-nigris onusto*" (Müller, loc. cit.) is no *Plagiogyria.* Baker[14] also reported *P. adnata* from Fiji and said it was the same as the Queensland species.

To the northeast, two species are common in Japan. A third, *P. adnata,* is reported, but the several Japanese specimens I have seen with this name represent aonther, and local, species. *Plagiogyria matsumureana* is especially interesting because of its evident near relationship to the group of American species. It presents the evidence that in this genus Japan was the western point of contact between the two continents.

The question of primitiveness of species within the genus is tied up with that of the direction in which the Pacific was crossed. Bower (in his earlier publication) was disposed to regard *P. semicordata* as primitive in the genus. If it is, the Pacific was probably crossed toward the west. My own present view is that *P. pycnophylla* and *P. adnata* are more primitive. The comparative wealth of the Old World, in known species and in their diversity, indicates greater age there. Both of the species just named are widely distributed. Each has been the apparent point of departure for the evolution of a number of

[11] Fragmenta 5 (1866) 187.
[12] Ferns of Queensland, pl. 87.
[13] Synopsis 183.
[14] Journ. Bot. 17 (1879) 295.

daughter species—those of *P. pycnophylla* in the southern part of the area, those of *P. adnata* in the north and northeast. If the genus had reached the Orient substantially in the form of *P. matsumureana*, this, instead of *P. pycnophylla* and *P. adnata*, should have established a range to India and Java. As I construe the evidence, the group of *P. adnata* evolved freely in China, established there a substantial dispersal pressure, and reached Japan in approximately the form of *P. matsumureana*. Thence it jumped the ocean, just once and by a single jump, and established itself with very little modification. From such a fern as this, the American species are presumed to be descended, but there has been in America no evolution of distinct groups of species, such as are evident in the Orient. On certain morphologic grounds, I might have picked *P. euphlebia* as the most primitive species; but I am unable to recognize these as presenting, in this instance, as strong a case as is established on geographic considerations.

The chief service of a treatise of this kind is to facilitate the study of the genus by others. Theoretically, it might be to make such study unnecessary; but the lesson of experience is that whenever a monograph is accepted for any considerable time as final, the result is that its field lags behind others. For the material assistance of other students, I have assembled here the original diagnoses of all species known to be *Plagiogyria*, giving, when necessary, an additional description of each species as I construe it. In a single instance, the original publication being in French after the adoption of international rules prescribing Latin, I have substituted a translation; otherwise, these republications are literal.

While a large part of the material serving for this study is in my own herbarium, I would be wanting in appreciation if I failed to acknowledge the help, in this and in several other studies carried on at the same time, given me by Dean Merrill and the botanical department of the University of California, in placing at my disposal their herbarium and library facilities. After practically completing the study of the Oriental species, I received, by the kindness of Mr. Maxon, the rich material of the United States National Herbarium; my study of the American species is based almost wholly on this collection. To Doctor Christensen, I am indebted for the opportunity of inspecting the type of *Lomaria pectinata* Liebmann.

Distribution of the Oriental species of Plagiogyria.

[The American species of *Plagiogyria* have not been collected and distinguished sufficiently to make their tabulation instructive.]

Plagiogyria.—	Celebes.	Java.	Sumatra.	Borneo.	Philippines.	Himalaya.	China.	Formosa.	Japan.
pycnophylla		×		×	×	×	×		
tuberculata			×	×	×				
glauca	×	×		×	×	×	×	×	
nana					×				
egenolfioides				×					
minuta				×					
rotundipinnata				×					
clemensiae				×					
euphlebia						×	×	×	×
christii					×		×		
grandis							×		
intermedia									×
adnata		×	×	×	×	×	×		
sumatrana			×						
assurgens							×		
stenoptera					×		×	×	
henryi							×		
petelotii							×		
falcata					×				
tenuifolia							×		
dunnii							×		
hayatana							×	×	
argutissima							×		
matsumureana									×
Total	1	3	3	8	8	4	14	4	3

Key to the species of Plagiogyria.

Oriental species; fertile pinnæ mostly narrowly linear.

1. Dwarfs, not glaucous.
   2. Sterile pinnæ narrow at base .... 10. *P. minuta.*
   2. Sterile pinnæ cordate or auricled .... 19. *P. egenolfioides.*
1. Not dwarfs, or glaucous beneath.
   2. Small ferns with obtuse pinnæ .... 8. *P. nana.*
   2. Large ferns with pointed pinnæ .... 7. *P. glauca.*
1. Not dwarfs nor glaucous, pinnæ mostly free.
   2. Apical leaflet like the others, and free.
      3. Subcoriaceous, brownish green.
         4. Pinnæ acuminate .... 1. *P. euphlebia.*
         4. Pinnæ finely caudate .... 3. *P. grandis.*
      3. Thinner and dark green .... 2. *P. christii.*
   2. Apical segment like pinnæ, but confluent .... 4. *P. intermedia.*
   2. Apex of frond pinnatifid.
      3. Margin toothed throughout .... 5. *P. pycnophylla.*
      3. Pinnæ entire except near apex.
         4. Pinnæ about 1.0 cm wide .... 6. *P. tuberculata.*
         4. Pinnæ about 1.5 cm wide .... 6. *P. sumatrana.*

1. Not dwarfs nor glaucous, most pinnæ adnate.
  2. Apical leaflet like others.
    3. Apical leaflet longer than others........................ 11. *P. rotundipinnata.*
    3. Apical leaflet shorter than medial........................ 12. *P. clemensiae.*
  2. Apex of frond pinnatifid.
    3. Lowest pinnæ extremely reduced.
      4. Pinnæ serrate, mostly contiguous at base.
        5. Frond linear-lanceolate.. 17. *P. petelotii.*
        5. Frond broadly lanceolate.
          6. Dwarfed lower pinnæ few........................ 15. *P. stenoptera.*
          6. Dwarfed pinnæ about ten.................................. 16. *P. henryi.*
      4. Pinnæ serrate, connected by a wing................. 14. *P. assurgens.*
      4. Pinnæ biserrate, contiguous............................. 22. *P. argutissima.*
    3. Lowest pinnæ not, or moderately, reduced.
      4. Lower pinnæ narrowed at base.
        5. Tubercles on rachis few or none......................... 13. *P. adnata.*
        5. Each pinna subtended by a tubercle............ 6. *P. sumatrana.*
      4. Pinnæ not contracted at base.
        5. Veinlets not forked... 18. *P. falcata.*
        5. Most veinlets forked.
          6. Teeth regular and simple.
            7. Segments lanceolate, acute......................... 19. *P. tenuifolia.*
            7. Segments narrower, acuminate.
              8. Segments near together......................... 20. *P. hayatana.*
              8. Segments their own width apart............ 21. *P. dunnii.*
          6. Segments irregularly biserrate............ 23. *P. matsumureana.*

American species; fertile pinnæ broadly linear. (For key to the American species see p. 406.)

1. PLAGIOGYRIA EUPHLEBIA (Kunze) Mettenius.

Plagiogyria euphlebia (Kunze) METTENIUS, Plagiogyria (1858) No. 6. (Cited by species number because there are two series of page numbers.)

Lomaria euphlebia KUNZE, Bot. Zeit. 6 (1848) 521.

Fronde oblonga, acuminata, coriacea, subtus pallidiore, pinnata; pinnis remotiusculis, erecto-patentibus, sterilibus lanceolatis, subfalcatis, marginatis, margine reflexo obtuse denticulatis, basi in petiolum brevem attenuatis, in rhachi subdecurrentem, superioribus adnatis, apice attenuato cuspidato-acuminatis, cuspide serrulatis, costatis, costa utrinque, imprimis, subtus elevata, depresso-canaliculata, puberula, venis distinctis, remotis, subtus elevatis, plerisque furcatis; fertilibus breviter petiolatis, linearibus, obtusis, subapiculatis, basi subcordatis, supra impresse fusco-venosis; rhachi stipiteque mediocri, quadrangulo, sulcato glabris, opacis, purpurescenti-fucis; rhizomate . . . . Japonia.—METTENIUS.

The caudex is stout, suberect, and buried in old stipe bases, as is characteristic of the genus. The stipes of sterile fronds are 15 to 30 centimeters or more long; of fertile fronds, commonly a little longer. The sterile frond is 30 to 60 centimeters long, 20 to 30 centimeters wide, pinnate; the sterile pinnæ usually about

ten on a side, the lowest not appreciably reduced, nor conspicuously deflexed; the medial ones nearly horizontal, narrowly lanceolate, acuminate or caudate and there sharply and rather coarsely serrate, elsewhere obscurely toothed. The pinnæ may all be free, but more commonly one or two of the upmost ones on each side are partly adnate; all are narrowed to the base, and nearly all are rather symmetrically and gradually narrowed and stalked; not subtended by tubercles. From the most of the genus, this and the following species are sharply distinguished by the large terminal leaflet, like the lateral ones, or with a lobe or two at the base; they are equally distinguished by having few, large, stalked pinnæ, not crowded together, and in the comparatively lax venation. The texture is described as coriaceous, but is really too thin in most specimens to be properly so designated. The color is either clear green or brownish green, the two surfaces practically alike. Altogether, the sterile frond has more the aspect of a *Stenochlaena* than that of other species of its own genus.

The accepted range is from Japan and Formosa across China to northern India. To this, van Alderwerelt adds Malacca and New Guinea; but the New Guinea fern I have received under this name is a *Lomaria*. Judging by the frequency of collection, it is common in Japan and China.

The Indian representatives were *Acrostichum triquetrum* of Wallich's Catalogue, and described as *Plagiogyria triquetra* by Mettenius.[15] Indian and Chinese specimens seem to average a little larger than Japanese, with the lowest pinnæ a little more remote; but the differences are both trivial and inconstant.

2. PLAGIOGYRIA CHRISTII Copeland.

Plagiogyria christii COPELAND, Philip. Journ. Sci. Suppl. 1 (2906) 153.

Caudice erecto, breve; stipitibus confertis, 20–30 cm. altis, glabris, castaneis, nitidis, basibus incrassatis, tuberculis carentibus; frondibus 40–60 cm. altis, pinnatis; frondis sterilis pinnis utrique ca. 13, fere horizontalibus, inferioribus brevissime pedicellatis superioribus adnatis, ca. 13 cm. longis, 15–20 cm. latis, acuminatis, serrulatis, glabris, herbaceis venis simplicibus vel furcatis; frondis fertilis pinnis utrinque 12–16, remotis, pedicellatis ver supremis adnatis, linearibus, 10 cm. longis, 2–3 mm. latis; sporis ad apices venularum confertis, primo margine membranacea inflexa protectis, dein margine retroflexa et sporangiis mox paginam totam complentibus, 0.3–0.4 mm. altis; annulis obliquis non interruptis.

MINDANAO, Zamboanga, monte Apo, *Copeland* 1509. Ad terram, 1,500 ad 1,800 m. s. m.—COPELAND.

[15] Plagiogyria (1858) 274, No. 5.

"Zamboanga" should have been omitted from the locality given for the type. More recently collected in Mindoro and again in Mindanao; also in Kwangtung, where the specimens agree perfectly in texture and color with those from the Philippines. This and the preceding species are very closely related—perhaps too closely. Judging by the collections to date, *P. christii* has larger fronds, with more numerous pinnæ (13 to 15 on a side) than are usual in *P. euphlebia*, thinner in texture, and distinct in color—very dark green above, paler and somewhat olivaceous beneath—and still laxer venation. Contrary to the published diagnosis, tubercles are present on the enlarged stipe bases, but feebly developed and inconspicuous; also, the lower pinnæ are "breviter," rather than "brevissime," stalked.

8. PLAGIOGYRIA GRANDIS Copeland, sp. nov. Plate 1.

Caudice crasso, erecto; frondis sterilis stipite 40 cm alto, basi trigono-dilatato externe utroque latere 3–4 tuberculis magnis praedito, sursum etiam tuberculis minoribus conspicuis usque ad 20 cm infra pinnas infimas ornato; fronde ca. 60 cm alta, 25–30 cm lata, pinnata cum impari simile, rhachi obtuse angulata, ad basin pinnae quaeque tuberculo minuto praedita; pinnis utroque latere ca. 15, alternantibus, infimis pedicellatis, plerisque sessilibus vel subsessilibus, supremis anguste adnatis, basi cuneato-retundatis, valde et angustissime caudatis, medialibus 20 cm longis, ca. 17 mm latis, infimis paullo minoribus, ubique serrulatis seu cauda remote serratis, papyraceis, olivaceis; fronde fertile ultra 40 cm alta, pinnis 15–20 cm longis, 2–3 mm latis, pedicellatis.

Kwei Chau, Pinfa, leg. Cavalerie; Rosenstock, Fil. Chin. No. 171. Type in the United States National Herbarium, Nos. 1096007, 1096008.

Nearly related to *P. euphlebia* Mettenius, and distributed under that name. It is larger than that species or *P. christii*, not blackish like the latter, and different from both in the finely long-caudate pinnæ, and especially from *P. euphlebia* in the absence of slender pedicels of the pinnæ. Correlated with its size is the strong development of the aërophores, on the flattened base, the rachis, and the upper part of the stipe.

The sporangia are large, with rather conspicuously oblique annulus, with about twenty-two thickened cells. The spores are tetrahedral, and very minutely rough. In and near the axils of the pinnæ there may be a cluster of minute hairs.

4. PLAGIOGYRIA INTERMEDIA Copeland, sp. nov. Plate 2.

Caudice suberecto, plerumque breve; frondis sterilis stipite usque ad 20 cm alto, fulvo, triangulare, basi applanato valde carinato aerophoris paucis et parvis praedito, frondis fertilis ca. 40 cm alto; fronde sterile 25–30 cm alta, ovata, costa superne prominula biangulare et sursum alata, inferne tereta, aerophoris carente; pinnis utroque latere ca. 15, infimis non abbreviatis sessilibus vel subsessilibus, sequentibus anguste adnatis, supremis confluentibus, segmento terminale aliter pinnis simile, medialibus 8–10 cm longis, ca. 12 mm latis, acuminatis, apices versus serratis, alibi integris, papyraceis, olivaceo-viridibus, venis plerisque furcatis; fronde fertile 30 cm alta, pinnis plerisque stipitulatis, 6–10 cm longis, 2–3 mm latis.

Japan. Type, *Faurie 160,* 1907, in herbarium Copeland No. 2742, Koyasan, in petrosis. Also, Yugashima, *Faurie 27,* 1912; Hieisan, Mrs. Knowlton; Oldham, 1862, ex Herb. Kew.

This species is intermediate between *P. euphlebia* and *P. adnata.* I have received it under both names, but the specimens in the United States National Herbarium all bore the former. It differs from this in the confluence of the upper pinnæ and adnate or sessile lower ones. It differs from *P. adnata* in the less adnate pinnæ and the absence of the marked tendency of their bases to run up the rachis. It is approached by *P. adnata* var. *distans.*

5. PLAGIOGYRIA PYCNOPHYLLA (Kunze) Mettenius.

Plagiogyria pycnophylla (Kunze) METTENIUS, Plagiogyria (1858) No. 2.

Lomaria pycnophylla KUNZE, Bot. Zeit. 6 (1848) 143.

Fronde tenuiter coriacea, opaca, glabra, subconcolore, oblongo-lanceolata, breviter acuminata, pinnata; pinnis sessilibus, approximatis, frondis sterilis patentibus lanceolatis, acuminatis, basi exciso-cuneata integerrimis, margine reliquo reflexo serrulatis, costa tenui, subtus sulcata, venis arctis, furcatis, supra prominulis, infimis abortivis; rhachi validiuscula, depressa, marginata, supra canaliculata, subtus bisulcata; frondis fertilis pinnis erecto-patentibus, linearibus, basi rotundata uniglandulosis, apice obtusiusculis; soris costam non obtegentibus; rhachi angulata, utrinque bisulcata; rhachibus stipiteque mediocri utriusque frondis rufescentibus, glabriusculis; caudice scandente sparsim paleaceo.

Ex insula Java communicavit cl. de Vriese (sub. L. scandente W.).

—METTENIUS.

Outside of Java, this is known from several mountains of Borneo and Luzon, where it is very abundant locally, and from southern and western China and northern India, where again it is locally common. The variety *mixta,* described from Luzon,

is no more than a local freak. The variety *remota* is a large form, such as seems to be commoner in India, found in Luzon only in sheltered spots.

This is like the preceding species and those immediately to follow, and unlike the majority of the genus, in being really pinnate unless immediately under the apex, where a few small "pinnæ" are united at their bases. It has uniformly smaller pinnæ than the preceding species, more coriaceous in texture, more evidently toothed, with more congested venation, and is most distinct in that the sterile pinnæ are truncate at their bases, and sessile, or the lowest very short-stalked, and these often deflexed, but not much reduced in size.

The stipes of the sterile fronds are often less than 10 centimeters long, but may reach several times this figure. The fronds are 30 to 60 centimeters long, or still longer, but most commonly near the smaller figure. The pinnæ are twenty or more on a side, usually separated by much less than their own width, usually acute and sharply serrate, but varying from obtuse to acuminate and subfalcate. In stunted, alpine forms, the pinnæ are obtuse, and may be almost entire. Typically, a small tubercle subtends each pinna, but this may be quite absent. Even the apex of the frond may not be constant; typically, it is pinnatifid, merging at the bottom into the fused upper pinnæ; but there are rare specimens, given this name, with an apical leaflet quite like the lateral ones.

The rachis and the upper part of the stipe are square in section, and range in color from stramineous to brown. The stouter and darker they are, the more likely are the tubercles to be evident.

6. **PLAGIOGYRIA TUBERCULATA** Copeland.

Plagiogyria tuberculata COPELAND, Philip. Journ. Sci. Suppl. 1 (1906) 153.

Rhizomate erecto, breve, valido; stipitibus permultis confertis, frondium sterilium 20–35 cm., fertilium 30–40 cm. altis, rhachibusque quadratis glabris nitidis rubido-brunneis basibus incrassatis aerophora ca. 12 ferentibus; rhachi infra insertionem pinnae tuberculum 1–1.5 mm. longum durum emittente, nec stipite eisdem minoribus remotis carente; fronde sterile ca. 60 cm. alta, 20–25 cm. lata, abrupte acuminata; pinnis 30–40-jugatis, fere horizontalibus, inferioribus brevi-pedicellatis basibus acutis, superioribus adnatis, supremis coadunatis, acuminatis apicibus rectis serratis, aliter integris, majoribus ca. 12 mm. latis, papyraceo-coriaceis, glabris; venulis simplicibus vel furcatis conspicuis; fronde fertile angustiore, mox desiccante, pinnis ca. 11 cm. longis, 2–3 mm. latis, patentibus.

LUZON, Lepanto, Bagnen, 1,900 m. s. m., *Copeland* 1924.—COPELAND.

Later collections extend the range of this species to Negros and Mindanao, and to Borneo and Sumatra. What was described as *P. pycnophylla* var. *integra* Copeland, Philip. Journ. Sci. § C 5 (1910) 285, is really a small *P. tuberculata.*

Plagiogyria tuberculata is a notably large fern, characterized by its shiny, dark stipes and rachises, from reddish brown to dark purple in color. This is an expression of the strong development of an impervious layer of mechanical tissue, in correlation with which the aërophores are remarkably developed, not merely subtending the pinnæ, but also on the stipe, for some distance below any pinna. The subcoriaceous, light green pinnæ are entire except at the apex. The lower ones are contracted on both sides and stalked, as in *P. euphlebia;* in the upper third, or sometimes two-thirds, of the frond, they are more or less completely adnate. The apex is typically and usually pinnatifid, but in a few specimens seen, not otherwise distinguishable, it is a simple leaflet or has one basal branch.

The var. *latipinna* Copeland, Philip. Journ. Sci. § C 2 (1907) 133, is a congested alpine form from Mount Halcon; in sheltered places near at hand grew fronds more ample than the typical. A slender form, from Negros, has been called var. *gracilis* Copeland, Elmer's Leaflets Philip. Bot. 2 (1908) 405.

PLAGIOGYRIA SUMATRANA Rosenstock, Fedde's Repert. **13** (1915) 214.

Rhizomate erecto, stipitibus fasciculatis (ad 10), brunneis, nitidis, profunde canaliculatis, basi dilatata exteriore tuberculis 1–2 utrinque instructa, foliorum sterilium ad 20 cm., fertilium ad 40 cm. longis; laminis sterilibus ad 50 cm. vel ultra longis, 18 cm. latis, elongato-oblongis, breviter acuminatis, subcoriaceis, laete viridibus, glabris, pinnatis; pinnis c. 25-jugis, alternis, erecto-patentibus, aerophoro tuberculiformi basi instructis, sessilibus vel inferioribus breviter petiolatis, superioribus basi infra late decurrenti adnatis, summis paucis inter se et cum pinna terminali, basi paucilobata, confluentibus; medialibus maximus c. 10 cm. longis, 1½ cm. latis, e basi cuneata oblongo-lanceolatis, acuminatis, margine indistincte crenulatis, versus apicem crenulato-serratis, inferioribus decrescentibus, basalibus c. 5 cm. longis; nervis patentibus, simplicibus vel furcatis; laminis fertilibus sterilibus subaequalibus vel latioribus, pinnis patentibus, ad 15 cm. longis, 3–4 mm. latis.—ROSENSTOCK.

Sumatra.

This is described as distinguished from *P. pycnophylla* by having a considerable part of the sterile pinnæ adnate and decurrent; from *P. tuberculata,* by having fewer tubercles, firmer texture, and erecto-patent, instead of almost horizontal, pinnæ.

As the cotype, Rosenstock, Fil. Sumatranae No. 127, United States National Herbarium No. 1096063, is not firmer in texture than *P. tuberculata* often is, and has four aërophores on each

side of the base, these distinctions do not seem to be constant; but the fertile pinnæ are wider than on any of my specimens of *P. tuberculata.* I do not regard them as distinct species.

7. PLAGIOGYRIA GLAUCA (Blume) Mettenius.

Plagiogyria glauca (Blume) METTENIUS, Plagiogyria (1858) 273.
Lomaria glauca BLUME, Enumeratio (1828) 204.

L. frondibus pinnatis, pinnis sesilibus sterilibus lineari-lanceolatis acuminatis basi rotundatis vel subcuneatis serrulatis glabris subtus niveis, terminalibus subadnatis, fertilibus angusto-linearibus, sterilium rachi marginata, stipite subtetragono glabro . . . Crescit in umbrosis Javae interioris.

Var. B. frondis sterilis pinna ultima subpinnatifida.

Crescit in silvis montis Gede.—BLUME.

This is probably the commonest, as well as the most beautiful fern in its genus. North of Java, Celebes, and Borneo, it is found on most Philippine mountains, and in Formosa, Yunnan, and Khasya.

It is very nearly related to *P. pycnophylla,* from which it shows no constant difference except in the glaucous coating of the back of the sterile fronds. Even this is variable. Sometimes it is thin enough for the green to show through; but as a rule it is dense enough to make the entire surface a clear color of its own, whether snowy white or pale blue. As Blume already knew, the form of the apex of the frond is unstable—about equally often a leaflet like the lateral ones, and a serrate-lobed apex formed by the fusion of potential leaflets.

Plagiogyria glauca varies conspicuously in the course of its range. In Java, where first described, it is a very large fern, said to reach a height of 150 centimeters, with pinnæ up to 2 centimeters wide, with caudate, very coarsely toothed tips, and not at all thick or hard. Mindanao plants are smaller, but not very different. In northern Luzon, the common form is Christ's var. *philippinensis,* much smaller, not at all caudate, and rigidly coriaceous; and this is the form known to me from the Himalayas. I would be disposed to distinguish it specifically, if sure I had not already done so, by the description of *P. nana,* to which Christ's variety is at any rate very close.

Inspection of the type of *Lomaria* (?) *lucida* Presl, Rel. Haenk. 52, might show that the name of this species requires change.

8. PLAGIOGYRIA NANA Copeland.

Plagiogyria nana COPELAND, Philip. Journ. Sci. § C 4 (1909) 114.

Plagiogyria gregis P. glaucae Mett. qua statura reducta, pinnis rigidis confertis obtusis conspicue differt. Stipite frondis sterilis 3–5 cm alto, frondis fertilis circiter 15 cm, aerophoris paucis; fronde sterile 10–13 cm

alta, 5–6 cm lata; pinnis approximatis vel infimis paullo remotis, fere omnibus liberis, sessilibus, circiter 6 mm latis, obtusis, minute serrulatis, rigide coriaceis, infra glaucis; fronde fertile circiter 10 cm alta, sat condensata, pinnis 25–35 mm longis, linearibus, falcatis.

LUZON, Province of Benguet, Mount Pulog, *For. Bur. 16306 Curran, Merritt, & Zschokke*, common in grass lands, altitude 2,850 m, *Copeland P. P. E. 113*.

This is conceivably a form of *P. glauca*, due to the very unusual environment, but is distinct in various respects beside the stature. Specimens growing in brush are of course decidedly less dwarfed, but they are still far from typical *P. glauca*.—COPELAND.

9. PLAGIOGYRIA EGENOLFIOIDES (Baker) Copeland.

Plagiogyria egenolfioides (Baker) COPELAND, Journ. Straits Br. R. As. Soc. No. 63 (1912) 72.

Lomaria egenolfioides BAKER, Kew Bulletin (1894) 7.

Caudice erecto, frondibus biformibus dense caespitosis subcoriaceis glabris lineari-oblongis simpliciter pinnatis, stipitibus elongatis gracilibus brunneis nudis frondorum fertilium longioribus, pinnis sterilibus linearibus obtusis crenatis basi utrinque auriculatis, inferioribus deflexis sensim minoribus, venis remotis erecto-patentibus immersis obscuris superioribus simplicibus inferioribus furcatis, pinnis fertilibus remotioribus multo minoribus . . . . Lamina sterilis 5–6 poll. longa, medio 12–15 lin. lata, stipite 1½–2-pollicari. Lamina fertilis 8–9 lin. lata, stipite 4–5-pollicari.—BAKER.

Sarawak, Mount Dulit.

This species gets its name from the strong superficial resemblance to *Egenolfia appendiculata*.

10. PLAGIOGYRIA MINUTA Copeland. Plate 3.

Plagiogyria minuta COPELAND, Philip. Journ. Sci. § C 10 (1915) 148.

Rhizomate erecto, breve, radicibus et basibus frondium densissime vestito; fronde sterile ca. 6 cm alta, 10–12 mm lata, stipite usque ad 1 cm alto et deorsum rachi quadrangulatis minute paleaceis; pinnis multis, alternantibus, sessilibus, 6 mm longis, 1.5–2 mm latis, obtusis, crenatis, coriaceis, glabris; venis simplicibus, utroque latere costae 3 vel 4; frondis fertilis stipite 3 cm alto, pinnis paucis, stipitatis, 2–3 mm longis, 1.5–2 mm latis, cordatis, margine retroflexa lata; annulo continuo, cellulis ca. 26.

Sarawak, locality unknown, native collector *No. 393*.

An evident and near relative of *Plagiogyria egenolfioides* (Baker) Copel. . . ., but much smaller throughout, and the sterile pinnae usually narrowed at the base instead of cordate or auricled.—COPELAND.

I have not now at hand a specimen of *P. egenolfioides*, but did have when describing *P. minuta*. The latter is now illustrated by the accompanying Plate 3. The two species represent a very distinct group, known only in Borneo. A similar local group is composed of the next two species.

11. PLAGIOGYRIA ROTUNDIPINNATA Bonaparte.

Plagiogyria rotundipinnata BONAPARTE, Notes Ptérid. No. 14 (1925) 484.

Stipite plusquam 20 cm alto, rhachique teretibus, purpureis vel castaneis, glabris, superne sulcatis; fronde sterile usque ad 30 cm alta, 8 cm lata, lanceolata-ovata, utrinque angustata, in pinnam aliis similem 8 cm longam desinente; pinnis lateralibus erecto-patentibus, lanceolatis, apices rotundatis versus attenuatis, basibus truncatis, tuberculis rhachi excrescentibus subtensis, basibus subdistantibus, deinde ob formam lanceolatam pinnarum contiguis, integris, coriaceis, costis inferne prominentibus, interdum purpureis; nervis aut simplicibus aut furcatis, inferne conspicuis; pinnis supremis adnatis, infimis sessilibus vel breviter stipitulatis; fronde fertile simile, pinnis utroque latere usque ad 25, 7 cm longis, 3 mm latis, ita fastigiatis ut frons linearis videtur.

Sarawak, summit of Mount Murud, altitude 2,400 meters.

12. PLAGIOGYRIA CLEMENSIAE Copeland, sp. nov. Plate 4.

Caudice et pede stipitis ignotis; fronde ca. 40 cm longa, 15 cm lata, rhachi fusca, valida, usque ad 10 mm crassa, ad basibus pinnarum tuberculis parvis nigris praedita, haud angulata nec carinata; pinnis permultis, imbricatis, infimis foliaceis 4 cm longis sessilibus, infra easdem auriculis minutis remotioribus pinnas substituentibus, medialibus 9 cm longis, 8 mm latis, de basi ad apicem rotundatam sensim angustatis, contiguis et deinde imbricatis, ad rhachin ipsam confluentibus, integris, coriaceis, foliola apicale lateralibus simile sed minore; costis utraque facie prominentibus; venis fere omnibus simplicibus; fronde fertile subaequale; pinnis utroque latere interdum ultra 50, medialibus 5–8 cm longis, anguste linearibus, inferioribus sessilibus, superioribus dilatato-adnatis, aut rectis et horizontalibus aut sinuatis aut valde incurvatis, margine scario mox retroflexo et pinnis deinde ut videtur ubique (ad ambas facies) fructiferis, soris confluentibus.

Borneo, Mount Kinabalu, at Paka Cave, altitude 3,000 m. s. m.

Originally identified and distributed as *P. adnata,* from which it is quite distinct, in fact and in appearance. It is, however, very near the preceding species, from which it seems to differ in the remarkably congested foliage and abortive basal pinnæ. To guard priority for Bonaparte's name, if the two species prove

eventually to be one, I have provided it with a Latin translation of his description, and given it priority of place here. Really, though, the publication of a French or English or German description shows the same contempt, both for rules and for the convenience of botanists the world over, as would the use of Russian or Japanese for the same purpose; and I propose, when it again becomes necessary for me to treat the plants in a case like this, to treat the vernacular description as without effect.

13. **PLAGIOGYRIA ADNATA (Blume) Beddome.**

Plagiogyria adnata (Blume) BEDDOME, Ferns Brit. Ind. (1865) pl. 51.
Lomaria adnata BLUME, Enumeratio (1828) 205.

L. frondibus pinnatis glabris, sterilibus sessilibus acuminatis basi sursum adnatis deorsum rotundatis apice dentatis, fertilibus breviter petiolatis angusto-linearibus, rachi stipiteque tetragonis glabris. . . . Crescit in sylvis montanis Karang Javae insulae.—BLUME.

Java, Sumatra, Borneo, Philippines, Formosa, Kwangtung, Yunnan, Khasya. Also reported from Japan, but the specimens I have received thence so named are *P. intermedia.*

The sterile fronds are, of course, not sessile, Blume's statement applying to their pinnæ. The stipes are 20 to 30 centimeters or more in length, slender, brown or maroon toward the base, the bases moderately dilated, with two to five small tubercles in each row. The upper part of the stipe is obscurely, and the lower part of the rachis more sharply, 4-angled, the upper face wider than the lower; upward, the angles flatten out beneath, but the axis is prominent above throughout, and somewhat channeled. The lower pinnæ of ample fronds are separated by more than their width, and the upper ones by less. The larger ones are up to 8 centimeters long on large fronds, and to 15 millimeters wide, but usually more slender, about horizontal in position, moderately curved carrying the tip upward, the lowest little or not at all reduced, usually acute but varying from obtuse in small forms to acuminate, sharply serrate at the apex, elsewhere serrulate or entire; the bases, as described by Blume, cut away quite to the costa in the lower side in the lower part of the frond, but the adnate upper side running up the rachis as a wing; farther up the frond, the lower side of the pinna gradually becomes adnate, and the wing stretches out to reach the succeeding pinna; and near the apex the pinnæ are broadly adnate, and separated by rounded sinuses. The apex is an acute or acuminate segment, sometimes shading through lobes into the adjacent lateral ones, sometimes broadly and obscurely lobed.

The texture is thinly coriaceous; color, clear or slightly brownish green on both sides; venation, lax, with almost all the veins forked.

Fertile fronds longer-stalked and a little smaller; the pinnæ narrowly linear, stalked in the lower part of the frond, then adnate, and dilated-adnate at the top. Tips of the fertile veinlets free. Sporangia about one-third millimeter long, on shorter stalks of about six rows of cells. Annulus variable, usually of a little over thirty cells, of which six to ten flattened ones represent the stomium. Spores tetrahedral, minutely warty. Open and immature sporangia are found together, but without very young ones in my observation.

Plagiogyria adnata occupies a central position in the genus, connecting the groups with free pinnæ with the larger one, typically extra-Malayan in its distribution, with confluent segments.

Rosenstock [16] describes two varieties:

distans, the lower pinnæ contracted at the base, not running up the rachis. KweiChou, AnHwei and CheKiang.

angustata, the lamina 60–70 cm. long, 5–8 cm. wide, with about 40 pinnæ on each side. In KweiChou.

PLAGIOGYRIA RANKANENSIS Hayata, Icones Form. 8 (1919) 151.

Rhizoma erectum plus minus ascendens. Stipes 13–14 cm. longus triangularis in sectione basi dilatatus subcomplanatus basi plus minus squamatus. Frons sterilis lineari-triangularis 30 cm. longa 18 cm. lata apice in ambitu cuspidata basi truncata pinnata, pinnis inferioribus longioribus, infimis plus minus reflexis, inferioribus horizontaliter patentibus lineari-lanceolatis 9 cm. longis 12 mm. latis apice acuminatis ad summum obtusis basi lateris inferioris valde contractis sed basi lateris superioris ad rhachin frondis decurrentibus margine minute denticulatis sursum ad acuminem serrulatis; textura tenuiter chartacea, rhachis frondis complanata anguste alata. Frons fertilis 30–40 cm. longa remote pinnata, pinnis linearibus crispato-recurvatis 5–10 cm. longis 1 mm. latis.

Formosa, Rankanzan, alt. 4900 ped.

Near *P. adnata* Bedd., but separable from it by the distinctly winged rhachis and much smaller terminal pinna.—HAYATA.

As *P. adnata* has the rachis winged the most of its length, and its apical segment is always small, it seems probable that *P. rankanensis* is not in fact distinct from it. We have a Formosan specimen, determined as *P. rankanensis* by Sasaki, which I take for a large *P. adnata*. The identification, already noted, of a distinct Japanese plant as *P. adnata* might very easily result in the demand for a new name for *P. adnata* itself.

[16] Fedde's Repert. 13 (1913) 122.

14. PLAGIOGYRIA ASSURGENS Christ.

Plagiogyria assurgens CHRIST, Bull. Soc. Bot. Ital. (1901) 293. Revised diagnosis and figure in Acad. Geog. Bot. Mans **15** (1906) 139, 142.

Rhizomate crasso, ob stipitum bases persistentes squamoso, nigro, basi stipitis dilatata externe glandulis 5 aut 6 notata, atrobrunnea. Stipitibus junioribus involutis squamis setiformibus nigris ⅓ cent. longis parce conspersis. Foliis sterilibus cum stipite (20 cm. longo) 70 cm. longis 16 cm. latis, rachi dilatata compressa, alternatim alata, supra viridi, subtus uti tota lamina coeruleo-glauca. Foliis fertilibus steriles superantibus, stipite 26 cm. valido, tereti nec alato, sulcato, rufostramineo, fronde 35 cm. longo 6 cm. lato, pinnis inferioribus valde remotis et abbreviatis (5 cm. distantibus) superioribus magis approximatis, omnibus superne aliquantulum obcurrentibus, assurgentibus, linearibus 6 cm. longis 3 mm. latis, sporangiis brunneis tectis.—CHRIST, 1906, loc. cit.

Sze-Chuen, Mount Omi.

Most marked, among the several species which show such a character, for the winging of the rachis by the carrying of the base of each pinna or segment upward along it.

Christensen[17] notes that *Lomaria deflexa* Baker (*Blechnum faberi* C. Christensen), collected in the same place, is identical with this.

15. PLAGIOGYRIA STENOPTERA (Hance) Diels.

Plagiogyria stenoptera (Hance) DIELS, Nat. Pflanzenfam. **1** Abt. 4 (1899) 282.

Blechnum stenopterum HANCE, Journ. of Bot. **21** (1883) 268.

Rhizomate parvo epaleaceo, foliis caespitosis petiolo sterilium 4–5 fertilium 8-pollicari angulato per totam longitudinem alula ½ lin. lata marginato sterilium lamina 5–8 pollicari membranacea subpellucida glaberrima lanceolata pinnatisecta segmentis utrinque circ. 20 ad 22 lin. longis 4 lin. latis basi lata adnatis basi superiore leviter v. vix producta rectis acutis margine serratis infimis abbreviatis rotundatis nervis tenuibus conspicuis simplicibus v. semel furcatis fertilium lamina 5–6 poll. longa segmentis linearibus acuminatis 15–18 lin. longis lineam latis, indusio submarginali membranaceo soros demum nudante.—HANCE.

Formosa, near Tamsui, altitude 3,300 feet. Known by subsequent collections, in Formosa, as well as in northern Luzon and Kweichau. As *Lomaria concinna* Baker, Journ. Bot. 23 (1885) 103, was apparently described from the same collection as *P. stenoptera*, its diagnosis is not here repeated.

Stipes short in proportion to length of frond; costa prominent, and curiously winged beneath; pinnæ closely plâced, lowest ones fully adnate, reduced and deflexed, or sometimes reduced to a pair of auricles (compare *P. henryi*) ; middle ones the long-

[17] Med. Göteborgs Bot. Träd. **1** (1924) 92.

est, acute, finely and sharply serrate near the apex, elsewhere obscurely toothed or entire, straight or only slightly falcate, clear green on both surfaces, thin in texture and the veins not crowded. The fertile pinnæ are likewise mostly straight, 2 to 3 millimeters wide, acute, the lowest hardly reduced, the fertile area contracted at the base, instead of dilated as in some species.

Fertile veinlets free; sporangia 0.25 millimeter long, on slender stalks (for *Plagiogyria*), of about five rows of cells; annulus of about eighteen thickened cells and eight to ten flattened ones; spores moderately 4-lobed, warty.

16. **PLAGIOGYRIA HENRYI Christ. Plate 5.**

Plagiogyria henryi CHRIST, Bull. Boiss. 7 (1899) 8.

Espèce charactérisée par la fronde atténuée brusquement vers le bas par le changement des pinnae en oreillettes rudimentaires demi-circulaires.

Rhizomate adscendente, basibus stipitum deciduorum dilatatis purpureo-brunneis profunde sulcatis latere exteriore corpusculis minutis rugolosis tecto, stipitibus pluribus fasciculatis, 10 cm. longis latere superiore profunde sulcatis, latere exteriore convexis, firmis, fronde sterili 40 cm. longa 9 cm. lata late lanceolata acuminata simpliciter pinnata apice anguste contracto serrato infra pinnatifido; pinnis numerosis (36 utroque latere) alternis densis basi adnatis sese tangentibus sinu acuto, pinnis 4½ cm. longis 8 mm. latis lanceolato-acuminatis infra minutissime, versus apicem acute serratis, versus stipitem in circa 10 auriculas ½ cm. longas rotundatas abrupte desinentibus, textura tenuiter herbacea colore laete viridi faciebus nudis, nervis simplicibus aut furcatis liberis densis.

Fronde fertili breviore sed stipite longiore praedita, pinnis remotis, infimis petiolulatis linearibus 3 cm. latis erectis, basi frondis fertilis iisdem auriculis ac in fronde sterili notata. Soris turgidis ochaceo-rufis indusium tegentibus.

Henry n. 9036.A. Mengtze E mounts. 6000′.—CHRIST.

Yunnan; found there, before Henry, by Delavay, and again by Henry No. 13475—the accompanying Plate 5—and in Kweichou by Cavalerie, Rosenstock's Fil. Chin. No. 75.

Cavalerie's specimen is more ample than Henry's, the middle segment of the sterile frond being more than 7 centimeters long.

17. **PLAGIOGYRIA PETELOTII Copeland, sp. nov. Plate 6.**

Rhizomate adscendente, parvo, radicibus et basibus stipitum emortuorum omnino occulto; stipitibus dense caespitosis, basibus paullo incrassatis 3 cm longis, 4 mm latis, interne planis, externe carinatis et tubercula biseriata ferentibus, stipitibus frondium sterilium 5–8 cm, fertilium 25 cm altis, gracilibus, inaequaliter quadrilateralibus, nudis; fronde sterile anguste lanceolata, 30–40 cm alta, 5–6.5 cm lata, in caudam pinnatifidam terminante, deorsum angustata; pinnis utroque latere 40–50, quarum ca. 5 infimis

ad auriculas 3 mm longas 5 mm latas reductis, sequentibus horizontalibus, medialibus maximis horizontali-patentibus 3–3.5 cm longis, praecipue apices versus minute serratis, basibus adnatis ca. 7 mm latis contiguis et inter se sinubus angustis acutis separatis, deinde ad apices acutas sensim angustatis, tenuiter papyraceis, olivaceo-viridibus; venis tenuibus prope rhachin furcatis alibi plerisque simplicibus; fronde fertile 15–20 cm longa, pinnis anguste linearibus, stipitulatis, majoribus ca. 5 cm longis, 2–3 mm latis.

Indo-China, Chapo, leg. Petelot No. 1656, July, 1924. Chapo is on the Yunnan border, and this is credited to China in the table of distribution of species.

This species is clearly characterized by its general slenderness, of the stipes and their bases, of the sterile fronds, and of the fertile pinnæ, as well as by the violent contrast in the length of the stipes of the sterile and fertile fronds.

Sporangia 0.30 to 0.35 millimeter long; annulus of about twenty thickened cells and ten to twelve flattened ones; spores tetrahedral to 4-lobed, minutely rough.

18. PLAGIOGYRIA FALCATA Copeland.

Plagiogyria falcata COPELAND, Philip. Journ. Sci. § C 2 (1907) 133, pl. 1, B.

Caudice erecto, 5 mm. crasso, basibus stipitum persistentibus profunde obtecto; stipitibus confertis frondium sterilium 7–10 cm., frondium fertilium 16–24 cm. altis, glabris, deorsum triangulatis, pedibus incrassatis aerophoris carentibus; fronde sterile ca. 20 cm. alta, 6–7 cm. lata, brevi-acuminata, fere vel usque ad rachin pinnata; pinnis proximis, adnatis nec basibus dilatatis, acutis, ca. 5 mm. latis, rectis vel subfalcatis, argute serratis vel rhachin versus integris, inferioribus valde deflexis, membranaceis, glaberrimis, nigro-viridibus; venulis conspicuis, fere semper simplicibus; fronde fertile 15–24 cm. alta, 2.5–4 cm. lata, acuminata, pinnata; pinnis falcato-arcuatis, 2–3 cm. longis, 2 mm. latis, inferioribus remotis.

—COPELAND.

Mindoro, Mount Halcon, 2,100 m. s. m., *Merrill 5960.*

Still known only from the type collection. Regarding the report of this species in Formosa, see note under *P. hayatana.*

This is the only species with practically all the veins of the sterile frond simple. Among the species with all the pinnæ or segments adnate, and especially among those with thin fronds, it is also notable for the dark color of both surfaces.

The fertile veins fork very close to the costa, and their thickened tips are free. Sporangia 0.25 millimeter long, on slender stalks of not more than five rows of cells; annulus of twenty to

twenty-four thickened cells and ten to twelve flattened ones; spores very strongly 4-lobed, apparently smooth.

Reëxamination, on the assumption that aërophores must be present, reveals specks on some of the bases; but only an examination made in that spirit detects any sign of them.

19. PLAGIOGYRIA TENUIFOLIA Copeland. Plate 7.

Plagiogyria tenuifolia COPELAND, Philip. Journ. Sci. § C 3 (1908) 281.

Stipitibus frondis sterilis 15 cm fertilis 25 cm altis rhachibusque glabris brunneo-stramineis, acute trigonis; fronde sterile oblonga, 16–20 cm longa, 8–9 cm lata, vix ad rhachidem in pinnulis adnatis partita; pinnulis medialibus 4–4.5 longis, 8 mm latis, acutis, apicem versus grosse obtuse serratis, sinubus angustis interpositis, pinnulis inferioribus paullo reductis, infimis valde deflexes, glabris, herbaceis; fronde fertile ca. 10 cm alta, pinnis utrinque ca. 12, 2–2.5 cm longis, inferioribus stipitatis, rhachidem versus haud hastatis; annulis non interruptis.

Ma On Shan, 450 m. s. m. *Matthew 51*.—COPELAND. [Kwangtung Province, China.]

Fertile pinnæ up to 2.5 centimeters long and 3 millimeters wide, obtuse. Sporangia 0.3 millimeter long, open and immature ones mixed. Annulus of eighteen to twenty thickened cells and eight to ten stomium cells, the two kinds meeting, below, at the side of the insertion of the pedicel. Spores convex-tetrahedral.

This is distinguished from the others in its group by its broad, short fronds. The linear, but not narrowly linear, fertile pinnæ suggest the American species, but the texture and serration are distinctively Chinese.

20. PLAGIOGYRIA HAYATANA Makino.

Plagiogyria hayatana MAKINO, Tokyo Bot. Mag. 23 (1909) 245.

Rhizome erect, or ascending. Stipes triquetrous, exalate, shorter than the frond, about 12–20 cm. long, the base depressed-triquetrous and more or less dilated. Frond glabrous, more or less firm, oblong or narrowly oblong, acuminate, very deeply pinnati-parted, 30–50 cm. long, 12–17 mm. broad; segments numerous, close but sometimes subremote, patent or patent-divergent, but usually somewhat reflexed in basal ones, linear-lanceolate, subfalcate, acuminate, slightly dilated at the base, serrulated (the serration more conspicuous towards the apex), attaining about 9 cm. long, 1 cm. broad; midrib prominent on both sides; veins patent-divergent, bifurcate, simple in the superior ones; rachis carinate throughout beneath. Fertile fronds exceeding the sterile ones, long-stiped; pinnae remotely and simple-pinnately disposed, not secund, a little dilated and adnate at the base, angustate, patent or erecto-patent, the lower ones reflexed.

—MAKINO.

Formosa; also, China, as noted below.

The key that accompanies this description distinguishes this species from *P. matsumureana* by the flat back of the rachis of

the latter; and both of these from *P. stenoptera* by the criteria that the latter has the fertile pinnæ stalked, and the lower sterile pinnæ exceedingly reduced. A more significant difference from *P. matsumureana* is the absence of the toothed teeth of the latter.

Our authentic specimen of this fern, received with Sasaki's determination as *P. falcata*,[18] has only sterile fronds. It is not as slender a fern as *P. falcata*, nor as dark, has more-pointed leaflets, and differs most conspicuously in the venation. Judging by the fronds at hand, the segments of the sterile frond are variable in width as well as in closeness.

Without entire confidence, I identify with this a specimen collected in Anhwei by R. C. Ching, herbarium of the University of Nanking No. 8787. The sporangium is 0.3 to 0.4 millimeter long, with a stalk of five rows of cells. The annulus has about twenty thickened cells, and twelve conspicuously flattened stomium cells, the latter extending past the insertion of the pedicel, so that the sporangium ruptures very near its base.

21. **PLAGIOGYRIA DUNNII Copeland.**

Plagiogyria dunnii COPELAND, Philip. Journ. Sci. § C 3 (1908) 281.

Stipite frondis sterilis 20–25 cm alto glabro, ad basin aerophoris paucis donato, brunneo-bialato, rhachideque acute carinatis; fronde 40 cm alta, 10 cm lata, acuminata, fere ad rhachidem pinnatifida; pinnis medialibus 5 cm longis, 5 mm latis, plerumque rectis, acuminatis, apices versus serrulatis, glabris, tenuibus, sinubus latitudine pinnas saepe superantibus separatis, inferioribus plus minus diminutis, paullo deflexis, supracurrentibus; fronde fertile 25 cm alta, pinnis pede sterile adnatis, utroque latere plusquam 35, infra mediam frondem 5 cm longis sursum sensim decrescentibus.

Ad montem Yenping, 900 m. s. m. *Dunn 3934*.—COPELAND. [Fokien Province, China.]

The sporangia of the type, which is the only collection to date, are immature. As they are, they are a scant quarter millimeter in length, and the stomium cells, not yet fully differentiated, appear to be placed as in most other species, so that the rupture of the sporangium will not take place as close to the base as in the Anhwei plant just described. Too few species and specimens have been examined to establish the stability of this character.

This and the preceding species are very much alike. The segments of the sterile frond of *P. dunnii* are more remote, separated by almost their own width even close to the apex; but

[18] Cf. Icones Form. 4 (1914) 239.

still the affinity is very marked. *Plagiogyria dunnii* is the older name.

22. PLAGIOGYRIA ARGUTISSIMA Christ.

Plagiogyria argutissima CHRIST, Bull. Acad. Geog. Bot. Mans 20 (1910) 141, pl. 2.

Très voisin de *P. semicordata* (Presl) des Andes de l'Amérique.

Stipite pennae corvinae crassitie, rufo supraque cum rachi fulvo-stramineo, 7 cent. longo, lamina sterili oblonga acuminata deorsum angustata et in meras auriculas trigonas laceratas 5 mill. longas desinente, 40 cent. longa, media 10 cent. lata, pinnata, fere ad rachim divisa, pinnis pectinato-confertis recte patentibus, inferioribus abbreviatis deflexis, 35 utrinque, 5 cent. longis, 1 cent. latis, late et aequaliter adnatis, cuspidatis, acutissime biserratis, nervis manifestis sed tenuissimis ca. 20 utrinque, plerumque a basi aut medio furcatis.

Lamina fertili ad basin iisdem auriculis ac in lamina sterili instructa, pinnis contractis remotis linearibus, inferioribus stipite tenui ½ cent. longo praeditis et ex auriculis dilatatis et decurrentibus emergentibus 5½ cent. longis 2 mill. latis acuminatis, superioribus sessilibus. Sporangiis faciem inferiorem tegentibus, fulvis. Textura flaccide herbacea tenui, colore laete virente, faciebus glabris.

Hab. Rivière Taitchen (Pin-fa) décembre 1908, N. 3392, leg. Cavalerie.—CHRIST.

Known to me only by this description, which makes it seem to be a very distinct species.

23. PLAGIOGYRIA MATSUMUREANA Makino.

Plagiogyria matsumureana MAKINO, Tokyo Bot. Mag. 8 (1894) 333.

Caudex short, robust. Fronds dimorphous. Stipes fasciculate, rather stout, naked, 7–10 cm. long, but those of fertile ones longer, the base triquetrous, dilated, subcarnose, and furnished with a few minute glands. Sterile fronds pinnatipartite almost to the rachis, oblong-lanceolate, 30–50 cm. long, 10–17 cm. broad; segments numerous, approximate, horizontally patent, linear-lanceolate, acuminate, acutely duplicato-serrate, membranaceous; middle segments the largest, 5–8 cm. long, 7–14 mm. broad. Veins forked, erecto-patent; venules free, fine, sometimes forked. Fertile fronds pinnate, lanceolate; pinnae distant, mostly alternate, patent, contracted into elongated narrow-linear with acutely obtuse apex, the base dilated and adnate to the rachis. Sori linear. Indusium narrow, membranaceous.—MAKINO.

Japan, Shinano, Mount Komagadake (type locality), and in many other places. The fern once reported in Formosa under this name is *P. hayatana*.

Apparently identical with this is—

Lomaria (*Plagiogyria*) *fauriei* CHRIST, Bull. Boiss. 4 (1896) 666.

Stipe anguleux, jaunâtre, à base enflé, noire, à écailles claires peu nombreuses, subulées. Plante glabre, vert-jaunâtre. herbacée.

Fronde stérile, longue de 45 cm., large de 10 cm. ovée-oblongue, acuminée. Rachis non ailé. Pinnae se racourcissant assez brusquement vers la

base de la fronde, nombreuses (40 à 45 de chaque côte), sessiles sur un rachis à large base, très serrées de manière à ne pas laisser de sinus entre elles, se touchant par les bords, longues de 5 cm., larges de 1 cm., lancéolées-linéares, acuminées en pointe fine, bidentées, à dents aigues et souvent bifurquées. Nervures visibles mais non saillantes, assez serrées, bifurquées à la base. Fronde fertile à pinnae plus distantes, étroites, linéaires. [Here follows comparison with *P. semicordata.*]

Doit être également assez près de Blechnum stenopterum Hance, de Formose, qui m'est inconnu. [Here follow comparisons with *P. adnata* and *P. euphlebia.*]—CHRIST.

I have an excellent specimen of this fern from Faurie, his No. 5613, first identified as *P. matsumureana* and then changed to *L. fauriei;* the fronds are larger than indicated by either diagnosis, but otherwise it conforms perfectly to that of *P. matsumureana.* It may be noted that, while Christ avowed his ignorance of *P. stenoptera* when publishing *L. fauriei,* there is no indication that he was cognizant at all of *P. matsumureana.* Three years later, in publishing *P. henryi,* he was silent about *P. stenoptera.*

Each exterior face of the enlarged stipe base bears one or two inconspicuous aërophores. Sporangium, 0.25 to 0.3 millimeter long; annulus of about twenty-two thickened cells, the flattened stomium cells less differentiated than in most Oriental species, apparently eight to ten; spores tetrahedral to moderately 4-lobed.

This is not only more like the American *P. semicordata* than is any Oriental species; it is more like *P. semicordata* than it is like any other species in its own part of the world. The irregular double serration is a very conspicuous common character.

DOUBTFUL SPECIES

PLAGIOGYRIA SCANDENS Mettenius, Plagiogyria (1858) No. 4.

Truncus?; folia coriacea, glabra, difformia, pinnatisecta, apice?; segmenta sessilia, infra ad insertionem aërophoro exserto aculeiformi vel rotundato instructa, ala angustissima decurrentia, inferiora remota abortiva; foliorum sterilium petiolus 9″ longus, lamina ovato-oblonga, segmenta 8–10 juga, patentia, 3½″ longa, 6‴ lata, e basi inferiore?, superiore truncata, oblongo-lanceolata, acuminata, acute dentato-serrata; nervi secundarii prominuli, ¾‴ distantes, sub angulo 70° decurrentes; foliorum fertilium segmenta breviter petiolata, 4–5″ linga, 2–3‴ lata, flaccide curvata, linearia, margine attenuato integerrima; nervi secundarii prominuli, arcu intramarginali anastomosantes; sori partes supremas nervorum occupantes, denique confluentes.

Stenochlaena Griff. in herb. Kunzea.

Khasya (Griffith).—METTENIUS.

This was construed as *P. adnata* by Hooker and by Beddome, and is reduced to *P. pycnophylla* by Christensen; I do not know

if either identification is sanctioned by consultation of the original plant. The sessile segments, and especially the aërophores on the rachis, support the judgment of Christensen, but the abortive lower segments do not, nor does the marginal veinlet of the fertile pinnæ.

THE AMERICAN SPECIES OF PLAGIOGYRIA

Plagiogyria has been represented in the American Tropics by two species recognized as such, with the following names:

1. PLAGIOGYRIA SEMICORDATA (Presl) Christ, construed as including—

    Lomaria pectinata Liebmann.

    Lomaria arguta Fée, which I try to construe.

    Lomaria fialhoi Fée et Glaz.

    Plagiogyria biserrata Mettenius.

2. PLAGIOGYRIA COSTARICENSIS Mettenius: Kuhn.

This species is unknown to me. It may have been collected only once; and it is not too certainly a *Plagiogyria*. Mettenius should, indeed, have judged competently in this matter, but his specimen was destitute of caudex and stipe; the sporangia are not mentioned by him; and the description of the venation strongly suggests another genus.

To these two may be added—

3. BLECHNUM URBANI Brause.

These ferns are evidently not rare, from central Mexico and Porto Rico to Bolivia. In spite of the difficulty which all dimorphous ferns present to collectors, they are numerous in herbaria, always as *P. semicordata* or *P. biserrata,* however various in appearance. They constitute, indeed, a far more homogeneous group than do the Oriental species of the genus, and, as already indicated, a younger group, naturally less rich in species. Still, I am unable to regard nearly all of the ferns ticketed with these names as reasonably to be regarded as a single species.

The comparative homogeneity of American, as contrasted with Oriental *Plagiogyria,* is shown first by the common frond design of all the species—that of the group typified in the Orient by *P. adnata,* carried to America in somewhat the form of *P. matsumureana.* Beside this, the American species seem all to be less woody than are many of the Oriental ones. Their enlarged stipe bases, and the stipes and rachises, must be rather fleshy when fresh; for they collapse in drying, so that the bases, in herbarium specimens, are flattened, rather than three-ridged. Corresponding with this peculiarity of the texture, there is a

comparative absence of aërophores. I can find no trace of them on the rachis of even the stoutest American species; and on the enlarged bases, they are invisible on some, and hardly more than suggested, if present at all, on others.

With the limited material previously available, I had prepared a description of one species (which I now construe as *P. arguta*) and been content with noting others as not properly *P. semicordata.* With the far richer collection of the United States National Herbarium in hand, I now undertake to describe the most clearly marked other species. This treatment is still not exhaustive, even as to the plants in hand; but I am constrained to leave the work in this unfinished condition, by uncertainty as to what is properly referable to the old species. As will be noted presently, when the diagnoses are quoted, Presl, whose specific name has been so widely applied, had for description only a fragment, which probably would not permit positive identification with any complete plant, even if it were available for comparison. Since the name can hardly be discarded, no better course is left than to follow precedent, and accept *P. biserrata* Mettenius as a synonym, thereby getting Mettenius's description, figures, and plants as bases of identification. As a rule, when Mettenius described a plant, it can be identified, but in this case, not having his specimens as evidence, I suspect that he did more than describe a plant—that he described two of them. Until this question can be cleared up, I am leaving *P. semicordata* a "collective species," but a far more homogeneous one than I have found it.

Key to the American species of Plagiogyria.

1. Margin of segments or pinnæ entire.......................... 32. *P. costaricensis.*
1. Margin subentire, pinnæ long-acuminate.......................... 31. *P. urbani.*
1. Margin denticulate .... 29. *P. denticulata.*
1. Margin serrate, teeth not very unequal.
   2. Pinnæ or segments obtuse.......................... 30. *P. obtusa.*
   2. Pinnæ acute or acuminate.......................... 25. *P. semicordata.*
1. Margin serrate, teeth not uniform.
   2. Frond gradually much narrowed below.
      3. Lowest pinnæ quite remote.......................... 24. *P. arguta.*
      3. Lowest pinnæ not very remote.......................... 25. *P. semicordata.*
   2. Base not much narrowed; large ferns.
      3. Base of many fertile pinnæ abruptly narrowed on both sides. 26. *P. anisodonta.*
      3. Most bases not dilated on lower side.
         4. Veins near rachis only once forked.......................... 27. *P. maxoni.*
         4. Some twice-forked veins everywhere.......................... 28. *P. latifolia.*

24. PLAGIOGYRIA ARGUTA (Fée) Copeland, comb. nov. Plate 8.

Lomaria arguta FÉE, Huitième Mémoire (1857) 70.

Frondes stériles lancéolées, glabres, à segments profondément dentés, dents en scie; les fertiles plus longues, portées sur un long petiole ayant l'aspect d'une tige de *scirpus*, et renferment plusieurs faisceaux vasculaires (3?), devenant libres par le dessèchement du tissu cellulaire que ce pétiole renferme à l'état vivant; segments fertiles linéaires, flexueux.

Mexique, vallée d'Orizaba, Cerro del agua, à 2,700 mèters d' altitude. (W. Schaffner, no. 98; 1854.)

Dimensions: frondes stériles, 46 centim. sur 8–9 centim. d'envergure; segments, 8 millim. a la base; frondes fertiles, 65–70 centim.; le pétiole est à la lame : : 2 : 1.—FÉE.

This description is so defective that the best treatment it could receive has been reduction to *P. semicordata;* moreover, it is understood that the type specimen has been effectively lost for many years. When, however, the attempt is made to discriminate the species hitherto merged in *L. semicordata,* it becomes expedient, if possible, to identify this one. There are specimens in the United States National Herbarium that conform to Fée's specifications, unless it be as to the bundles in the stipe, and I am assigning his name to them. Such are: *Charles L. Smith 2063,* from the Sierra de Clavellinas, Oaxaca, altitude 9,000 feet; *Rose and Painter 7598,* near Etzatlan, Jalisco; and *Pringle 8958,* from the state of Puebla. These seem to be rather small forms of a fern better exemplified by *Pringle 4999,* which I regarded as a new species, before seeing the others. Its description is given, without a new name, to supplement or substitute Fée's.

Fronde sterile 75 cm alta, 15 cm lata, ad basin pinnata, utrinque angustata, herbacea, utraque facie viride; costa straminea, applanato-quadrangulata; pinnis infimis 2–3 cm longis, adnatis, subfalcatis, remotis; sequentibus 10- ad 15-paribus sensim accrescentibus 4–5 mm latis, spatie 15 mm lato separatis, ala angusta sursumcurrente confluentibus; medialibus 8 cm longis, 7 mm latis, rectis, spatio aequilato separatis, sensim acuminatis, apices versus argute irregulariter biserratis, alibi serrulatis; supremis coadunatis in apicem acuminatam frondis mergentibus frondis fertilis stipite ultra 50 cm longo, valido, rufo-stramineo; fronde 80 cm alta, 10 cm lata, pinnata; pinnis infimis abbreviatis valde remotis (4–5 cm inter se distantibus), subsessilibus; medialibus usque ad 7 cm longis, 3–4 mm latis, venulis incrassatis fructiferis liberis.

Mexico, Oaxaca, by brooks, Sierra de Clavellinas, altitude 2,700 m. s. m., *C. G. Pringle 4999.* Distributed as *Lomaria attenuata* Willdenow.

The sporangia are one-third millimeter or more long, on pedicels longer than the sporangia, of about five rows of cells, slender for the genus; annulus of about twenty thickened cells and about ten thinner ones at the stomium; spores tetrahedral, minutely roughened.

This is clearly a relative of *P. semicordata* (Presl) Christ, as most positively shown by the margin of the sterile frond, but is larger, more slender throughout, and especially distinguished in appearance by the long drawn out lower part of the frond.

Both *Lomaria attenuata* Willdenow and *L. meridense* Klotzsch are real *Lomaria,* or *Blechnum.*

25. PLAGIOGYRIA SEMICORDATA (Presl) Christ.

Plagiogyria semicordata (Presl) CHRIST, Farnkräuter (1897) 176.

Lomaridium ? semicordatum PRESL, Epim. Bot. (1849) 155.

Fronde fertili oblongo-lanceolata glaberrima pinnata, pinnis patentissimis linearibus obtusis basi inferiore cordatis superiore adnatis, fasciculo vasorum stipitis hippocrepico, sporangiis in seriebus semiannularibus discretis.

Habitat in sylvis Columbiae (inventor ignotus).—PRESL.

As Presl had neither caudex nor sterile frond, and the fertile frond is poor material for specific identification, I omit his further description.

Plagiogyria biserrata METTENIUS, Plagiogyria (1858) 272.

Truncus obliquus diametri 1″; folia chartacea rigida flavo-viridia glabra, difformia, sterilium petiolus 1–4″ longus, stramineus, anguste alatus, lamina 1–1½′ longa, lanceolata vel lato-lanceolata, acuminata, pinnatisecta, apice pinnatifida; segmenta numerosa, e medio utrinque decrescentia, media 1½–2½″ longa, 4–5‴ lata, patentia vel patenti-divergentia subfalcata basi sursum paullulum dilatata adnata et ala angusta herbacea vel callosa coadunata, oblongo- vel elongato-oblongo-lanceolata, acuminata, inaequaliter vel duplicato-argute serrulata, superiora approximata, inferiora subdistantia, basi inferiore soluta, decrescentia; nervi secundarii manifesti, ½‴ distantes, sub angulo 60° decurrentes, indivisi vel furcati, dentes intrantes; foliorum fertilium petiolus 2–3″ longus; lamina 1¼–2′ longa, elongato-lanceolata; segmenta subdistantia, oblique patentia, 1–3″ longa, 2–2⅓‴ lata, basi sursum dilatata adnata et ala angustissima sulcis lateralibus petioli abscondita, coadunata, linearia, obtusa, margine attenuato subscarioso subrevoluto dilacerata; nervi secundarii 1–1½‴ distantes, indivisi vel furcati, liberi, parte superiore incrassati; sori nervorum partem incrassatam occupantes vix vel paullulum in parenchyma nervis interjectum producti, denique confluentes, et totam paginam inferiorem, costa excepta, occultantes, margine revoluto vix velati.

Columbia, Col. Tovar (Moritz 400). Merida (Linden 556). Mexico (Karwinsky).—METTENIUS.

In technical systematic botany this is the type of the genus; and the first specimen cited is the type of the species, as *P. biserrata.* However, the reduction of *P. biserrata* to *P. semicordata* is generally accepted, and Presl's defective specimen thus becomes the specific type.

Lomaria pectinata Liebmann, cited as a synonym of this species, requires especial attention, because if identifiable as such, it probably has priority. The description is of a sterile frond, "so characteristic that one cannot do other than recognize a *Lomaria* in it," which might, indeed be a *Plagiogyria,* though its segments are notably narrow. It was said to grow on oak trunks—"Voxer paa Egestammer"—but this was probably a mistake, for the genus is very strictly terrestrial. Doctor Christensen was kind enough to send me the type specimen for inspection. It is a small, sterile frond; positively enough a *Plagiogyria,* but not referable to any species in our present state of knowledge of the juvenile stages of the American species. It is not at present worth while to transfer the name. Plate 15 is a photograph of Liebmann's type.

Plagiogyria ? aequidentata Fournier may be dismissed in the same way. Only a sterile frond was ever seen. It had crenate leaflets, and very probably belonged in some other genus.

26. **PLAGIOGYRIA ANISODONTA** Copeland sp. nov. Plate 9.

Stipitibus validis, fulvis vel fuscis, sursum rhachibusque obtuse quadrangulatis; fronde sterile ca. 80 cm alta, ultra 25 cm lata, deorsum haud angustata, in apicem lanceolatam 4.5 cm longam leviter pinnatifidam abrupte angustata, papyracea, laete virde; pinnis inferioribus 2–4 cm remotis liberis et medialibus anguste confluentibus spatio 5–8 mm lato separatis usque ad 15 cm longis, 12 mm latis, subhorizontalibus, sensim acuminatis, versus rhachin serrulatis, apices versus grosse et irregulariter inciso-serratis, costa utraque facie prominente, inferne biangulato-applanata, fulva; venis distantibus, plerumque ad costam geminatis et infra mediam laminam saepe furcatis, angulo ca. 60° cum costa et margine in dentes intrantibus; fronde fertile 60–75 cm alta, abrupte caudata, deorsum vix angustata; pinnis infimis remotioribus (4 cm remotis) adnatis, medialibus et superioribus ad rhachin abrupte utrinque dilatatis, superioribus ala angusta sterile connexis, medialibus et inferioribus usque ad 12 cm longis, 3–4 mm latis.

Costa Rica, extinct crater of Mount Poas, altitude 2,800 m. s. m., *O. Jimenes 1018,* 1915. Type in the United States National Herbarium, three sheets, Nos. 865089, 865090, and 865091; also, ibidem, *Standley 34895,* and *Conduz 10714* (both of these smaller than the type, but still large ferns).

In the distal half of each pinna, the product of the forking of each main vein or pair of geminate veins affects the margin as a unit, feeding into an obscure and shallow lobe or crenation, which in turn is very sharply toothed. Nine or ten veinlet-tips, each in its tooth, occupy a centimeter of margin. The annulus is oblique and often crooked, passing clear of the pedicel, with about twenty-one thickened cells. It is distinctly wider than in the two species to follow, and more oblique. The spores are tetrahedral, or sometimes 4-lobed, and very minutely roughened.

Hardly separable from this, although distinct in appearance, are Costa Rica specimens with simply forked veins and correspondingly uniform margin. They are usually smaller, and may be regarded as imperfectly developed; they agree perfectly in microscopic characters. Such are: *Pittier 2920,* from Poas; *Pittier 10498,* from Cerro de las Vueltas, altitude 3,000 meters; another specimen of Conduz, probably misnumbered 11261; and at least a part of the sterile specimens distributed by Christ from Werkle's collection, without number.

27. **PLAGIOGYRIA MAXONI** Copeland sp. nov. Plate 10.

Caudice adscendente; stipitubus frondis sterilis 12–20 cm, fertilis ca. 30 cm altis, deorsum et basibus dilatatis nigrocastaneis, sursum rhachibusque stramineo-viridibus, obtuse applanato-quadrangularibus; fronde sterile 50 cm alta, ca. 18 cm lata, deorsum vix vel paullo angustata, sursum subabrupte in caudam parvam lobatam contracta, papyracea; pinnis infimis ca. 6-paribus suboppositis liberis basi basiscopice exaratis, acroscopice anguste sursumcurrentibus, medialibus ala angustissima connexis, basibus fere aequilateralibus, maximis 10 cm longis, 9 mm latis, acuminatis, rhachin versus obscure, apices versus argute et grosse irregulariter serratis cum lobis obscuris saepius tridentatis; venis patentibus, prope rhachin furcatis, media longitudine saepe bis furcatis, ad marginem versus apicem segmenti curvatis; fronde fertile usque ad 40 cm alta, ca. 10 cm lata, deorsum moderatim angustata, caudata; pinnis medialibus 6 cm longis, 4 mm latis, plerisque basi basiscopice rotundatis, acroscopice adnatis, solummodo supremis dilatatis.

Jamaica, summit of Blue Mountain Peak, altitude 2,100 to 2,200 m. s. m., *Maxon 9910,* 1926. Type in United States National Herbarium No. 1302136; also, Mossman's Peak, *Maxon 9721. Maxon 1439,* 1903, from Blue Mountain Peak, is a stunted specimen.

Distinguished by the slender segments, the lower ones somewhat narrowed toward the rachis. About ten teeth occupy one centimeter of the margin. The annulus has twenty to twenty-two thickened cells, and is decidedly oblique. As the sporangium matures, in this and in other species, these cells are the first to thicken and discolor; then the two to four cells beside the stomium thicken, while still isolated, the more feeble differentiation of the cells between these and the ends of the elastic ring being the last step. The stomium cells are less widened in this species than in any other examined. The spores have three almost flat faces, the fourth remaining strongly convex; they are densely tuberculate.

28. **PLAGIOGYRIA LATIFOLIA** Copeland sp. nov. Plate 11.

Stipite frondis sterilis 45 cm, frondis fertilis 50 cm altis, fulvis, gracilibus; fronde sterile 70 cm alta, 25 cm lata, deorsum vix angustata, sursum ad segmentum terminale lanceolatum 4–5 cm longum acuminatum pinnatifidum sensim angustata, papyracea; pinnis inferioribus liberis vix remotis, inframedialibus subhorizontalibus ca. 13 cm longis, ca. 11 mm latis, ala fere obsoleta connexis, spatio ca. 6 mm lato separatis, valde acuminatis, prope rhachin denticulato-serrulatis, alibi argute lobulato-serratis; venis saepe bis furcatis; fronde fertile 40 cm alta, caudata, deorsum paullulum angustata; pinnis fere omnibus liberis, patentibus, medialibus 8 cm longis, 3–4 mm latis, basi acroscopice paullulum dilatatis.

Peru; Cani (a pueblo 7 miles northeast of Mito), altitude ca. 2,550 m. s. m., *J. Francis McBride 3432,* 1923. Type in the United States National Herbarium, two sheets, No. 1193294, sterile frond, and No. 1193293, fertile and immature sterile fronds.

The margin responds to the character of the venation by forming obscure lobes or crenations, each receiving all the forks of a main vein, and bearing as many teeth as a main vein has branches (geminate veins acting as one in this relation). The teeth are sharp and deep; and, because the veins are widely divergent from the costa, not exceedingly unequal-sided. Thirteen to fifteen veinlets run to each centimeter of margin. The

annulus, with eighteen to twenty thickened cells and a dozen flattened ones, is only moderately oblique, somewhat sinuous or irregular, and slender. The thickened cells hardly pass beyond the side of the pedicel, so that the stomium opens low on the side of the sporangium. The spores are tetrahedral and minutely tuberculate.

29. PLAGIOGYRIA DENTICULATA Copeland sp. nov. Plate 12.

Stipite trigono et rhachi tetragona superne late sulcata fulvis vel ferrugineo-fulvis; fronde sterile 60 cm alta, medio 15–18 cm lata, deorsum modo angustata, sursum sensim ad apicem acutam contracta, tenuiter coriacea; pinnis infimis liberis, vix 2 cm remotis, medialibus et superioribus basi confluentibus, sinu anguste rotundato vix 0.5 mm a rhachi remoto et usque ad apicem frondis vix remotiore; segmentis medialibus fere horizontalibus, 8–9 cm longis, 7–8 mm latis, medio longitudine ipsorum ca. 3 mm inter se remotis, potius acutis quam acuminatis, minute denticulatis, costis praecipue inferne prominentibus, plus minus ferrugineo-tinctis; venis saepe bis furcatis, in margine hyalinis, angulo subrecto in dentes intrantibus, dentibus ita subaequilateralibus; fronde fertile modo minore, 45 cm alta; pinnis remotioribus fere omnibus liberis, medialibus 6–8 cm longis, supra basin 4 mm latis, basi acroscopice dilatatis, basiscopice interdum exaratis.

Bolivia, leg. Th. Herzog "im Nebelwald des Bergkammes der Laguna verde bei Comarapa. 2600 m. April 1911. No. 1954." Type in the United States National Herbarium No. 1191649. Also, leg. Buchtien, 1908, Nord-Yungas, altitude 3,300 meters. Also, probably, Peru, Yanano, altitude 1,800 meters, *McBride 3830*, 1923.

The venation is very fine and close, consequent on the double forking of many veins, each branch of which enters a minute tooth, these standing about twenty to a centimeter of margin. The wide angle at which the veinlets strike the margin results in almost equal-sided teeth, so that the margin is denticulate, instead of serrate, as are most species. The annulus is slender, for *Plagiogyria*, with eighteen to twenty thickened cells, just oblique enough to pass the pedicel. The spores are tetrahedral or somewhat 4-lobed, and minutely tuberculate.

The specimen cited from Peru has a more serrulate margin and wider fertile pinnæ.

This is nearly related to the preceding species, and the two constitute a reasonably distinct group, characterized by the very ample fronds and congested venation. The margin of the sterile frond distinguishes clearly between the two.

30. PLAGIOGYRIA OBTUSA Copeland sp. nov. Plate 13.

Rhizomate adscendente; stipite frondis sterilis ca. 8 cm alto, frondis fertilis duplo altiore, sursum rhachique superne sulcatis, quadrangularibus; fronde sterile 20–25 cm alta, 5 cm lata, tenuiter sed rigide chartacea; pinnis infimis 1 cm longis deflexis, sursumcurrentibus, liberis vix remotis; segmentis medialibus horizontalibus, spatio 3 mm lato separatis, sinu obliquo, supramedialibus maximis, 25 mm longis, 6 mm latis, plerisque obtusis, apices versus argute alibi obscure serrulatis, costis et apicibus venularum ferrugineis, venis simplicibus vel saepius furcatis, proximis; fronde fertile 15–20 cm alta, 3 cm lata, pinnis infimis 15–20 mm remotis 8 mm longis, maximis supramedialibus 16 mm longis, 2–3 mm latis, apud rhachin inconspicue dilatatis.

Cuba, near Pico Turquino, *Leon 11126*, 1922. Type in United States National Herbarium No. 1049927.

Clearly distinguished by small size, narrowly oblanceolate fronds, and rigidity. About twenty veinlets reach each centimeter of margin, at such an angle that the minute teeth are very oblique. The annulus is oblique enough to pass clear of the pedicel and the adjacent cells; about twenty cells are thickened. The spores are minutely but densely tuberculate.

31. PLAGIOGYRIA URBANI (Brause) Copeland comb. nov. Plate 14.

Blechnum urbani BRAUSE, in Urban, Symb. Antil. 7 (1911) 158.

Lomaria; rhizomate erecto, cr. 6 cm. longo, cr. 6 mm. crasso, folia fasciculata emittente; foliis sterilibus fertilibusque inaequalibus, petiolatis; petiolis crassis (basi cr. 4 mm.), melleis, basi fuscescentibus, supra canaliculatis, infra teretibus, usque ad basin undulato-alatis, fertilibus cr. 25 cm., sterilibus cr. 7 cm. longis, basi dense, ceterum sparse paleis ferrugineis integris mox deciduis obtectis; rachibus supra canaliculatis, glabris, infra sulcatis, sparse paleis ferrugineis mox deciduis intructis, crassis; laminis sterilibus cr. 23 cm. longis, 7 cm. latis, ambitu lanceolatis, ad basin versus angustatis, in apicem pinnatifidum desinentibus, pinnatis, coriaceis, supra et infra glabris; pinnis cr. 25–30-jugis, approximatis sinu rotundato conjunctis, alternis, horizontaliter patentibus, basalibus angustatis refractis, e basi lata sessili lineari-lanceolatis in apicem serrulatum acuminatis, maximis 4 cm. longis, 6 mm. latis, serratis vel biserratis, infra glandulosis; costis supra glabris, infra paleis mox deciduis vestitis; venis lateralibus

obliquis, infra prominulis, simplicibus vel furcatis, usque ad 2 mm. inter se distantibus; laminis fertilibus cr. 26 cm. longis, ambitu lanceolatis, basi non angustatis, pinnatis; pinnis cr. 26-jugis, sessilibus, remotis, patentibus, ejusdem lateris cr. 1 cm. distantibus, ala angusta connexis, linearibus, maximis cr. 6 cm. longis, 2 mm. latis, marginibus involutis.

Hab. in Sto. Domingo prope Constanza in Valle nuevo 2200 m. alt. in pineto, m. Jun. 1910: H. von Türckheim n. 3408.

Diese Art fällt zunächst durch einige Absonderlichkeiten im Habitus auf . . . . Ferner findet man kaum wieder eine *Lomaria*-Art, welche so scharf und ungleichmässig gesägt ist wie diese hier . . . . Ueber die Schuppen konnte nicht viel gesagt werden, da an der Basis nur wenige verschrumpelte Reste, an der Rachis und der Costa nur wenige Spuren vorhanden waren.—BRAUSE.

This illustrates the familiar fact that one has only to place a plant in the wrong genus and it will quite certainly appear a very distinct novelty. The annulus is more oblique than is usual in *Plagiogyria*, being clear of contact with the insertion of the pedicel. There are about twenty-four typically thickened annular cells, and about twelve flattened cells, the stomium opening far up on the side of the sporangium. The spores are tetrahedral. The material at hand is a photograph of the type and some fragments, United States National Herbarium No. 1146952, showing no trace of the imputed paleæ; but, having been deceived in the same way with other species, I feel sure that the microscope would have shown that these were not peleæ, and were without cellular structure. They are dried-up flakes, remnants of the gelatinous cover of very young fronds.

The margin of the sterile pinnæ, described as remarkably serrate for a *Lomaria*, is remarkable in the opposite respect, for an American *Plagiogyria*. In its proper group, this can be recognized as a species by the relative entireness of these pinnæ (or rather, segments, for all but the lowest are connected by a wing), and by their long and gradual, not at all abrupt, attenuation. For half of their length, they are subentire; in the distal half, they are serrate, with very broad teeth, less than half a millimeter high. The shape of these teeth is a function of the very oblique direction of the veins.

22. PLAGIOGYRIA COSTARICENSIS Mettenius.

Plagiogyria costaricensis Mettenius: KUHN, Linnaea 36 (1869) 149.

Truncus deest; folia sterilia siccitate opaco viridia; lamina ultra 1′ longa, oblonga, basi abruptim attenuata, pinnatisecta; segmenta basi utraque aequaliter dilatata vel superiore latiore adnata, 3½″ longa, 5‴ lata, elongato-oblonga, subfalcata, apice attenuato, obtusa vel obtusiuscula, pleraque

contigua et ala angustissima confluentia, inferiora paullulum decrescentia, distincta, infima vel juga 2–3 infimorum distantia, transversa, abortiva; omnia margine revoluto attenuato subintegerrima; nervi laxi furcati vel more *Doodyae* anastomosantes, apice subincrassata supra sub foveola minuta desinentes; foliorum fertilium petiolus 11″ longus, rhachis straminea, tetragona, 1½′ longa, lanceolata, acuminata, basi brevius attenuata, pinnatisecta; segmenta laxe disposita, ultra 3″ longa, 2‴ lata distincta patentia, sursum adscendente adnata, deorsum soluta, linearia apice attenuato obtusiuscula, margine scarioso, attenuato, integerrima inferiora paullulum decrescentia, remota, utrinque soluta, infima 1¾″ longa; nervi distantes, furcati, apice incrassati, liberi, versus apicem et apice ipso sporangiis onusta porro ad basin marginis hyalini receptaculo lineari, sporangiis occupato, nervis destituto instructa.

Costa Rica, Vulcan de Barba (Wendland 1066).

A *Pl. biserrata* Mett., cui proxima, foliis integerrimis diversa.—KUHN.

242249——4

ILLUSTRATIONS

[Photographs by C. G. **Matthews.**]

PLATE 1. *Plagiogyria grandis* Copeland; type.
2. *Plagiogyria intermedia* Copeland; type.
3. *Plagiogyria minuta* Copeland; type.
4. *Plagiogyria clemensiae* Copeland; type.
5. *Plogiogyria henryi* Christ; *Henry 13475.*
6. *Plagiogyria petelotii* Copeland;, part of the type.
7. *Plagiogyria tenuifolia* Copeland; type.
8. *Plagiogyria arguta* (Fée) Copeland; *Pringle 4999.*
9. *Plagiogyria anisodonta* Copeland; above, cotype; below, fertile frond of type.
10. *Plagiogyria maxoni* Copeland; type.
11. *Plagiogyria latifolia* Copeland; type.
12. *Plagiogyria denticulata* Copeland; type.
13. *Plagiogyria obtusa* Copeland; type.
14. *Plagiogyria urbani* (Brause) Copeland; type.
15. *Lomaria pectinata* Liebmann; type.

PLATE 1. PLAGIOGYRIA GRANDIS COPELAND; TYPE.

PLATE 2. PLAGIOGYRIA INTERMEDIA COPELAND; TYPE.

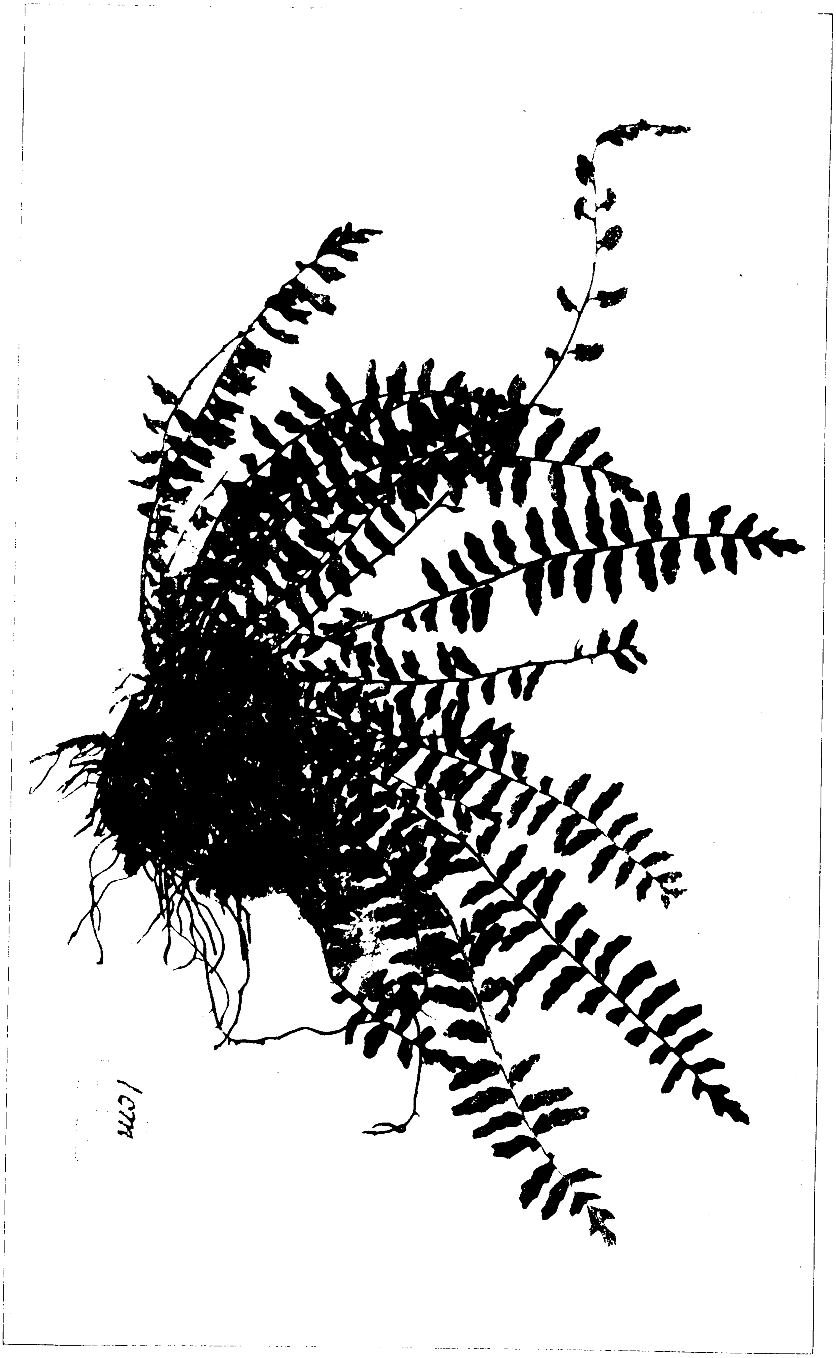


PLATE 3. PLAGIOGYRIA MINUTA COPELAND; TYPE.

PLATE 4. PLAGIOGYRIA CLEMENSIAE COPELAND; TYPE.

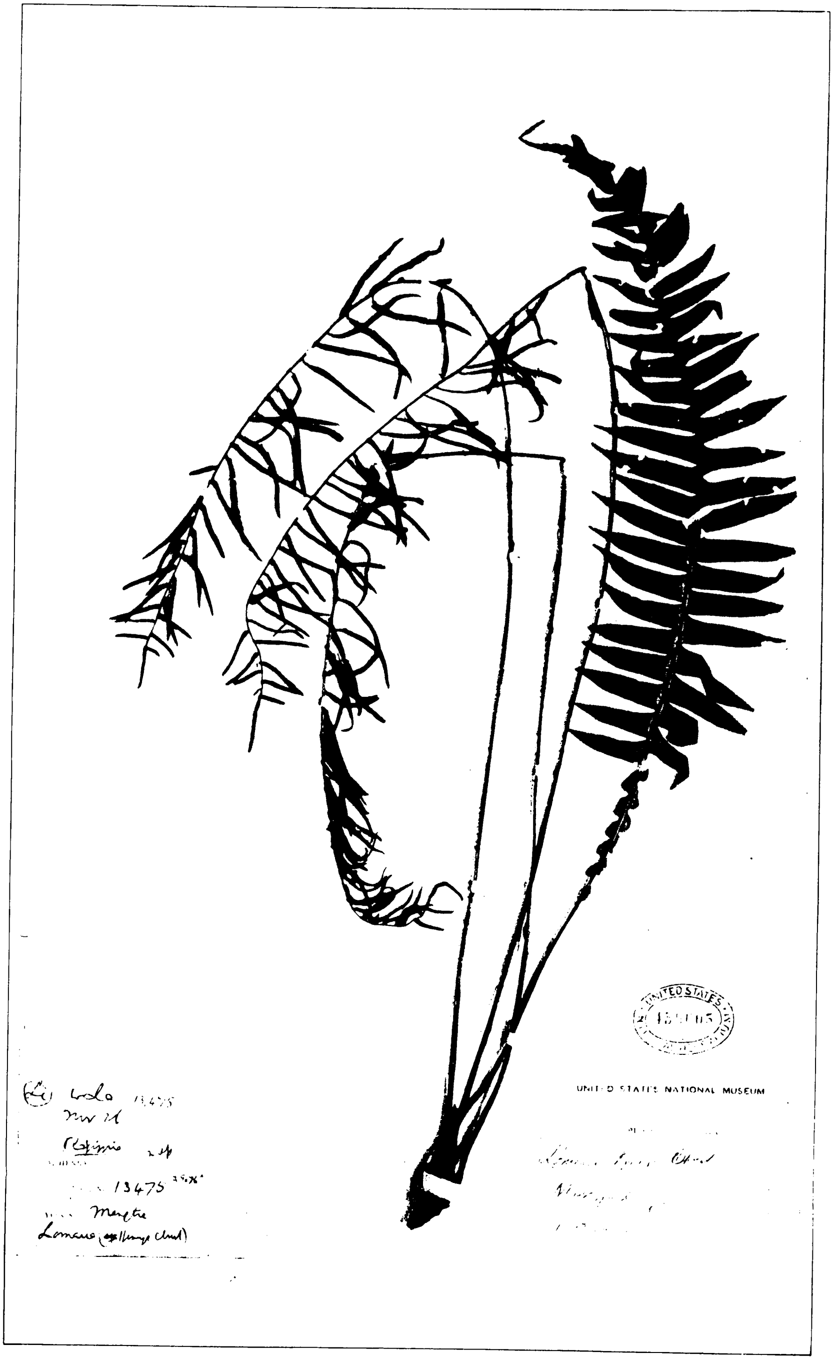


PLATE 5. PLAGIOGYRIA HENRYI CHRIST; HENRY 13475.

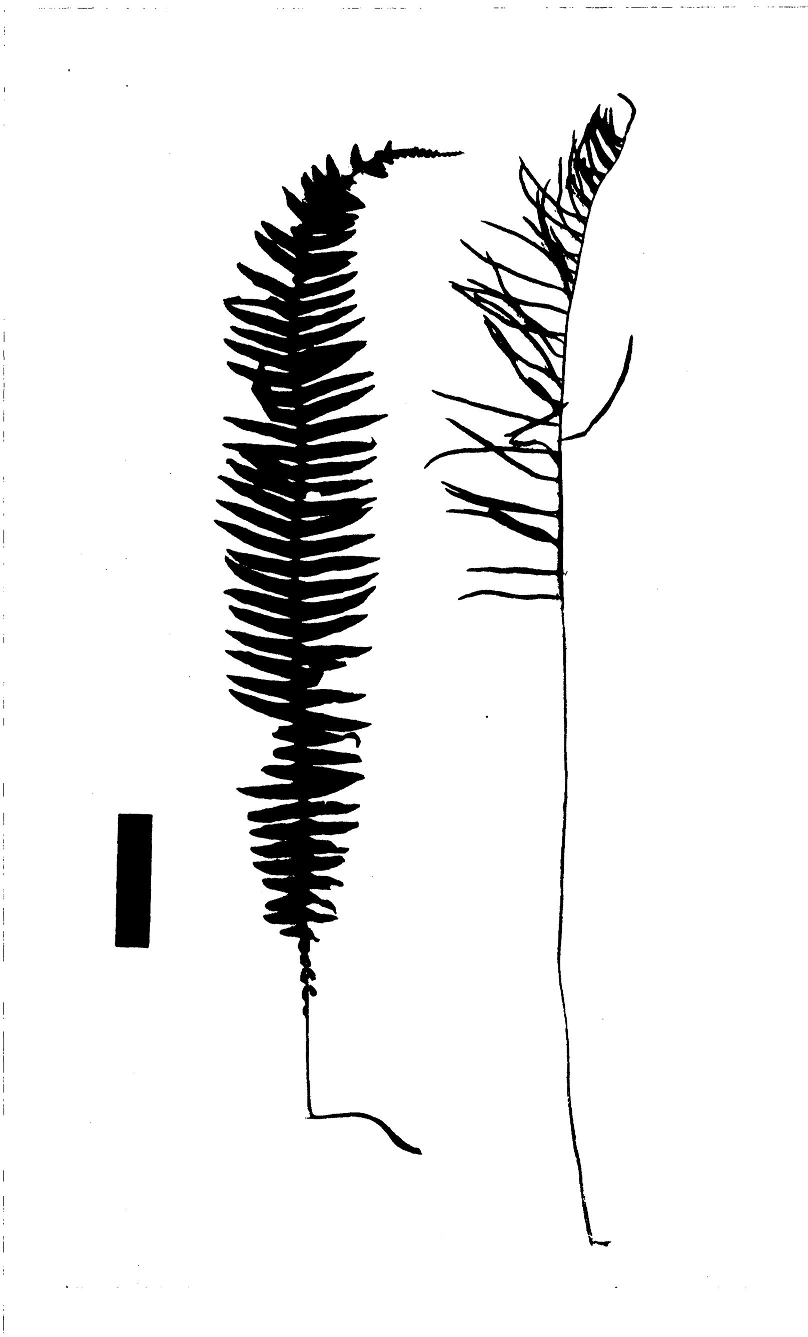


PLATE 6. PLAGIOGYRIA PETELOTII COPELAND; PART OF THE TYPE.

PLATE 7. PLAGIOGYRIA TENUIFOLIA COPELAND; TYPE.

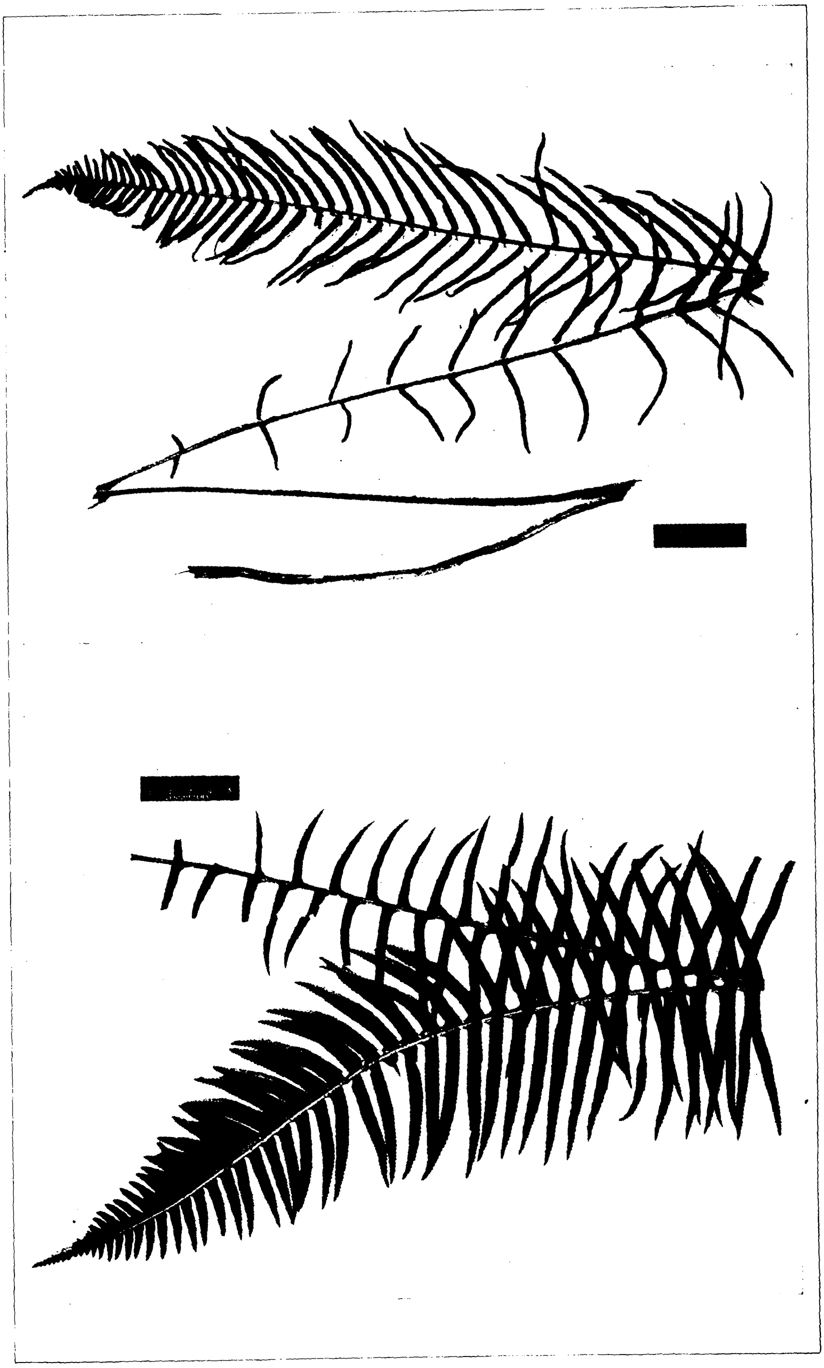


PLATE 8. PLAGIOGYRIA ARGUTA (FÉE) COPELAND; PRINGLE 4999.

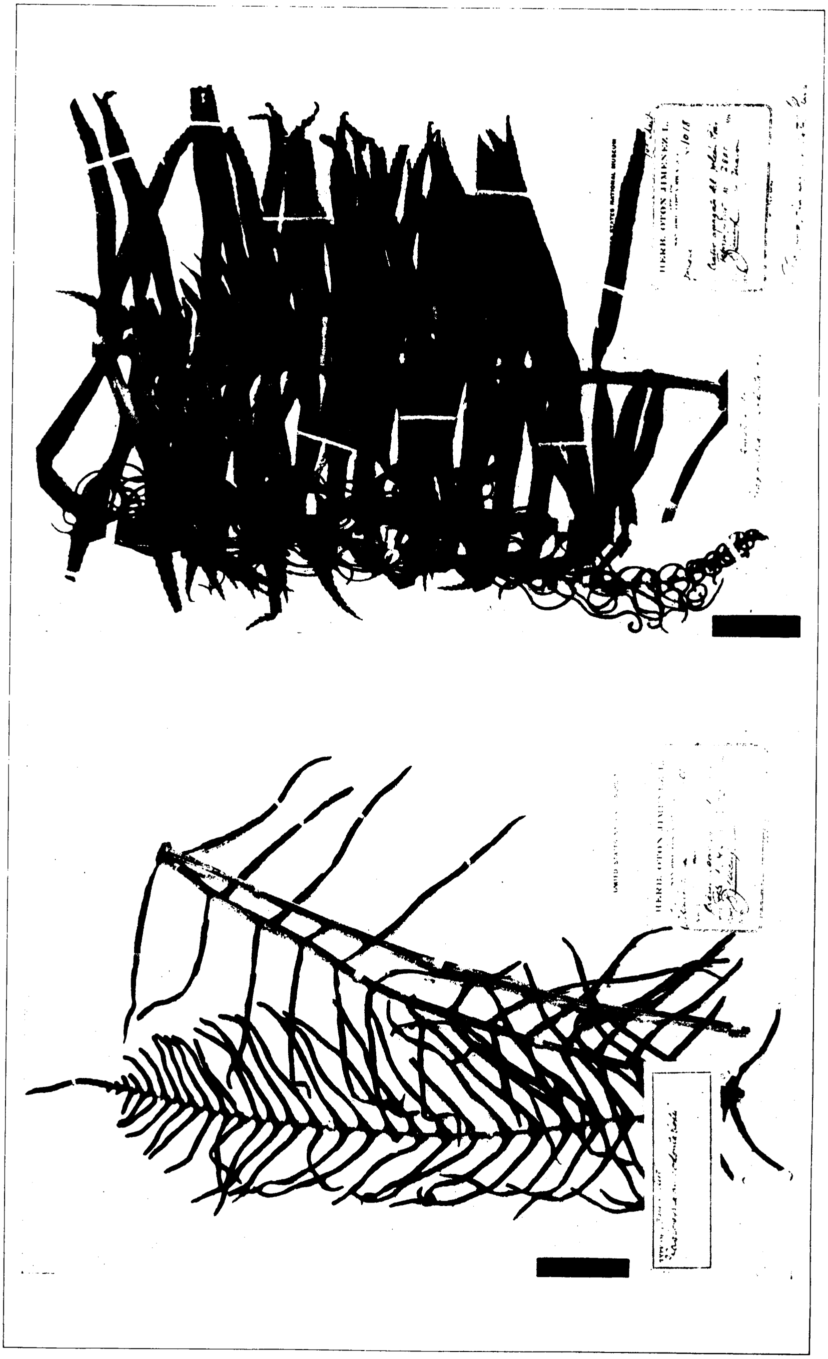


PLATE 9. PLAGIOGYRIA ANISODONTA COPELAND; ABOVE, COTYPE; BELOW, FERTILE FROND OF TYPE.

PLATE 10. PLAGIOGYRIA MAXONI COPELAND; TYPE.

PLATE 11. PLAGIOGYRIA LATIFOLIA COPELAND; TYPE.

PLATE 12. PLAGIOGYRIA DENTICULATA COPELAND; TYPE.

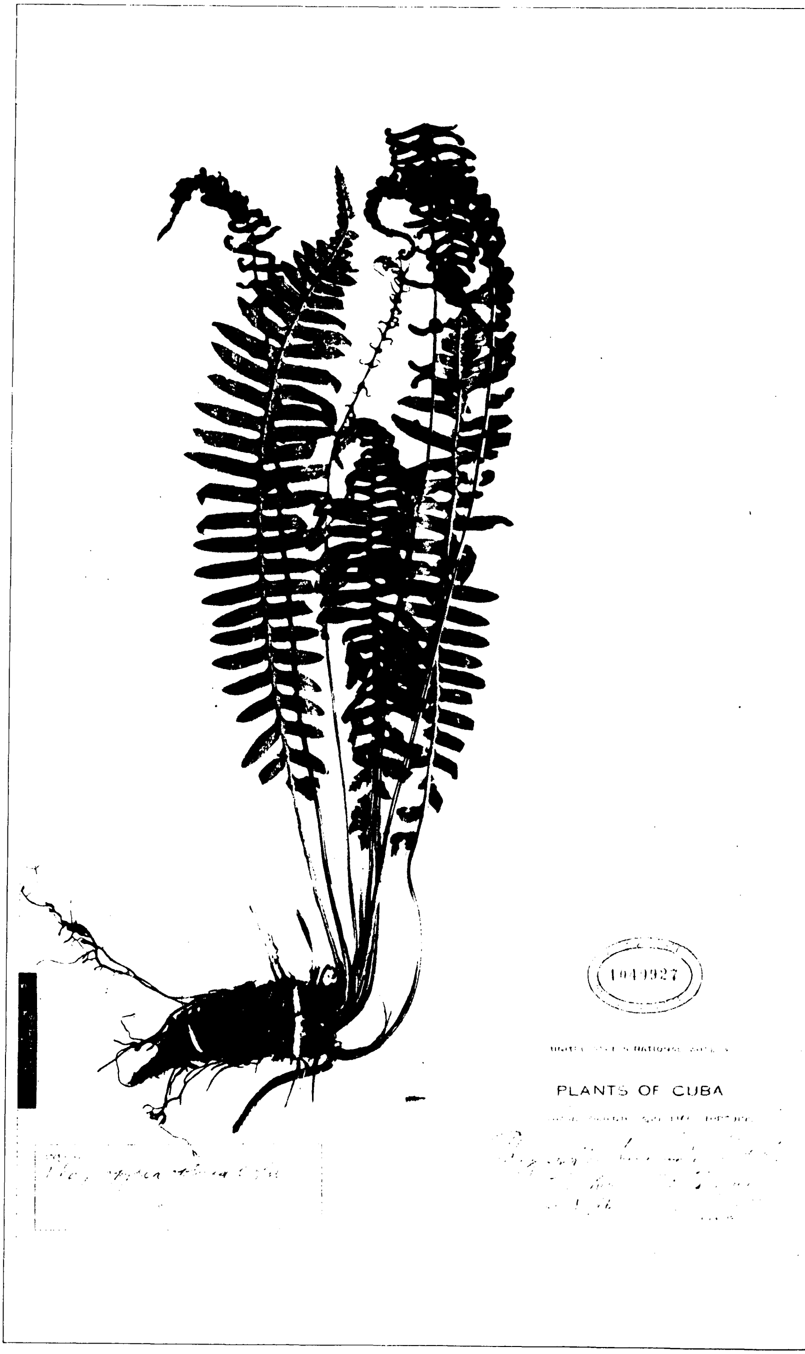


PLATE 13. PLAGIOGYRIA OBTUSA COPELAND; TYPE.

PLATE 14. PLAGIOGYRIA URBANI (BRAUSE) COPELAND; TYPE.

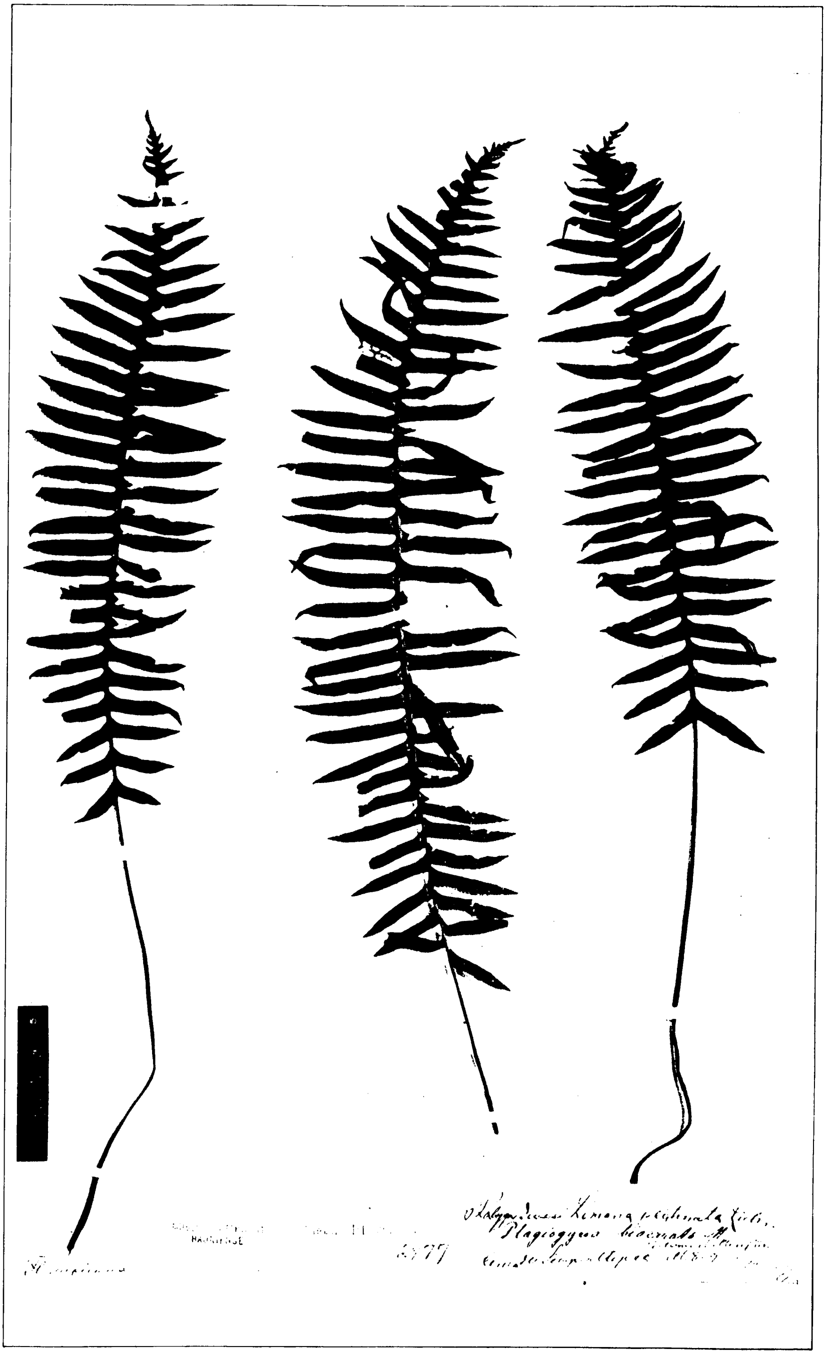


PLATE 15. LOMARIA PECTINATA LIEBMANN; TYPE.

MARINE DIATOMS FROM DAIREN, SOUTH MANCHURIA

By B. W. SKVORTZOW

Of Harbin, China

TWO PLATES

The diatoms living in the Yellow Sea and the Eastern Sea of China are relatively very little known. One enumeration of forms observed in samples from the environs of Ningpo and Nimrod Sound was published by P. Petit.[1] We find a small note, Grundroben aus den chinesischen Gewässern, gesammelt von Rudolf Rabenhorst fil. analysirt von Dr. Schwarz in Berlin, with description of a new *Triceratium*.[2] Some information about diatoms is also found in papers and monographs by A. Schmidt, P. T. Cleve, and A. Grunow. Three years ago N. Gist Gee[3] published an interesting list of diatoms from Soochow and Ningpo.[3]

So far as I know, there is no published list of diatoms from the northern part of the Yellow Sea or from Liaotung, and such a list I am giving in the present note.

In 1926, I received from my young friend A. Prosowetsky a small collection of sea mud, from oysters collected at Dairen. This mud was sufficiently rich in diatoms, and the present paper lists seventy-one species and varieties in twenty-one genera, including three new species and twelve new varieties and forms.

ACTINOPTYCHRUS UNDULATUS (Ehrenb.) **Ralfs.**

A. Schmidt, Atlas Diatom. pl. 1, figs. 1–6.

Diameter, 0.0255 mm; puncta, 16 to 18 in 0.01 mm.

COSCINODISCUS LINEATUS **Ehrenb.**

A. Schmidt, Atlas Diatom. pl. 59, figs. 27–30, 31, 32; pl. 114, fig. 13.

Frustule diameter, 0.0697 mm. Markings hexagonal, 2.5 in 0.01 mm, somewhat smaller towards the periphery. Border

[1] Memoires de la Sc. Nat. de Cherburg **23** (1881) 251–256.

[2] Hedwigia (1874) No. 11.

[3] Lingnaan Agr. Rev. **3** (1925) 151–155.

narrow, distinct. Geographic distribution: Kamtchatka Sea, Indian Ocean, Japan, California.

COSCINODISCUS RADIATUS Ehrenb.

Ehrenberg, Mikrogeologie pl. 19, fig. 1; A Schmidt, Atlas Diatom. pl. 60, figs. 5, 6, 9.

Diameter, 0.17 mm; markings, 2.5 to 3.5 in 0.01 mm. Geographic distribution: Caspian, North, Baltic, and China Seas, Atlantic Ocean, Japan.

COSCINODISCUS LENTIGINOSUS Janisch.

A. Schmidt, Atlas Diatom. pl. 58, fig. 11.

Diameter, 0.0724 mm. Markings round, granular, 8 in 0.01 mm. Geographic distribution: Patagonia, Antarctic Ocean, Oamaru deposit.

HYALODISCUS SUBTILIS Bailey var. JAPONICA Castracane.

Castracane, Report on the Diatomaceae collected by H. M. S. Challenger 1873–1876 p. 140. pl. 18, fig. 4. (Coast of the Japan Sea.)

Our specimens are 0.0544 mm in diameter.

BIDDULPHIA AURITA Bréb. var. ORIENTALIS Mereschkowsky.

C. Mereschkowsky, On Polynesian Diatoms, Scripta Bot. (1900–1902) 119, pl. 18; A. Schmidt, Atlas Diatom. pl. 120, figs. 5–8.

Length, 0.0306 mm; breadth, 0.0153; striæ, 12 in 0.01 mm.

BIDDULPHIA PULCHELLA Gray.

Length, 0.0935 mm; breadth, 0.0765; striæ, 4 in 0.01 mm. Common.

TRICERATIUM FAVUS Ehrenb. Plate 2, fig. 14.

A. Schmidt, Atlas Diatom. pl. 82, figs. 13, 14.

Diameter of the frustule, 0.1115 mm.

MELOSIRA SULCATA (Ehr.) Kütz. f. RADIATA Grun.

A. Schmidt, Atlas Diatom. pl. 176, fig. 22.

Diameter, 0.0221 mm; striæ, 15 in 0.01 mm.

MELOSIRA ARCHITECTURALIS Brun.

A. Schmidt, Atlas Diatom. pl. 177, fig. 48.

Length, 0.0069 mm; breadth, 0.017. Geographic distribution: Oamaru, Bains Tower.—*Brun and Gründler.*

CYCLOTELLA STRIATA (Kg.) Grun.

Diameter of the valve, 0.034 mm; striæ, 11 to 12 in 0.01 mm. Geographic distribution: Pacific Ocean, Japan Sea.

LICMOPHORA GRATIS Ehrenb. Plate 1, fig. 1.

Length, 0.0969 mm; breadth, 0.0119; striæ, 20 in 0.01 mm. Geographic distribution: Atlantic Ocean, Adriatic Sea.

GRAMMATOPHORA MARINA (Lynb.) Kütz.

Geographic distribution: Mediterranean Sea, Atlantic and Pacific Oceans, Japan Sea.

GRAMMATOPHORA JAPONICA Grun.

Length, 0.0578 mm; breadth, 0.0187; striæ, 18 to 20 in 0.01 mm.

CAMPYLODISCUS INTERMEDIUS Grun. Plate 1, fig. 2.

Length, 0.073 to 0.102 mm; breadth, 0.0697; striæ, 4 in 0.01 mm. Geographic distribution: South China Sea.

CAMPYLODISCUS SAMOENSIS Grun. Plate 1, fig. 6.

Length, 0.102 mm; breadth, 0.093; striæ, 3 to 4 in 0.01 mm. Geographic distribution: Mediteranean Sea, Pacific Ocean, South China Sea.

SURIRELLA LIAOTUNGIENSIS sp. nov. Plate 1, fig. 11.

Valve elliptic broad with rounded ends; length, 0.0306 mm; breadth, 0.0238. Rim broad and massive, marked with strong, closely set lines, without a median line.

SURIRELLA LIAOTUNGIENSIS var. **MINUTA** var. nov. Plate 1, fig. 12.

Valve small elliptic bisected with a line; length, 0.0187 to 0.0221 mm; breadth, 0.012 to 0.0153.

SURIRELLA FLUMINENSIS Grun. Plate 1, fig. 3.

Length, 0.0425 mm; breadth, 0.0305. Mediterranean Sea.

SURIRELLA FASTUOSA Ehrenb. Plate 1, fig. 7.

Length, 0.0629 mm; breadth, 0.0442.

SURIRELLA FASTUOSA Ehrenb. var. **CUNEATA** A. Sm. Plate 1, figs. 4, 5.

Length, 0.0578 to 0.0646 mm; breadth, 0.0323 to 0.0442; striæ, 2 to 3 in 0.01 mm.

SURIRELLA GEMMA Ehrenb. Plate 1, fig. 13.

Length, 0.0629 to 0.0935 mm; breadth, 0.034 to 0.04; striæ, 2 to 3 in 0.01 mm.

COCCONEIS SCUTELLUM Ehrenb. var. **JAPONICA** var. nov. Plate 1, fig. 8.

Cocconeis japonica A. SCHMIDT, Atlas Diatom. pl. 190, fig. 30, from Yokohama.

Length, 0.0272 mm; breadth, 0.0152. Valve with narrow axial area. Loculi large, arranged in longitudinal and transverse rows.

COCCONEIS SCUTELLUM Ehrenb. var. **PARVA** Grun.

Length, 0.017 mm; breadth, 0.0192. Geographic distribution: East Cape, Baltic and Adriatic Seas.

COCCONEIS SCUTELLUM Ehrenb. var. **ORNATA** Grun. Plate 1, fig. 9.

Length, 0.0459 mm; breadth, 0.0357; striæ, 5 in 0.01 mm. Geographic distribution: Kamtschatka and North Pacific Ocean.

COCCONEIS PSEUDOMARGINATA Greg. var. **FORMOSA** var. nov. Plate 1, figs. 14 and 15.

Valve elliptical; length, 0.029 to 0.0459 mm; breadth, 0.0204 to 0.032. Upper valve with narrow lanceolate axial area and narrow lunate lateral areas. Striæ between the areas, 18 to 22 in 0.01 mm. Lower valve with straight median line ending at some distance from the margin. Axial area narrow, central small. Typical *C. pseudomarginata* Greg. is found in Greenland, Spitsbergen, Kara, North, Mediterranean, and Red Seas, Madagascar, China, Sandwich Islands, and fossil in Hungary.

MASTOGLOIA FIMBRIATA Btw.

Length, 0.068 mm; breadth, 0.047. Geographic distribution: Mediterranean and Adriatic Seas, Mauritius, Madagascar, Japan, China, Australia, Oceania, Honduras, Brazil.

DIPLONEIS AESTIVA Donk. forma β. Plate 1, fig. 10.

Length, 0.0255 mm; breadth, 0.021; striæ, 12 or 13 in 0.01 mm. Geographic distribution: Sweden, Sumatra.

DIPLONEIS LINEATA Donk. Plate 1, fig. 17.

Length, 0.0459 mm; breadth, 0.017; striæ, 9 or 10 in 0.01 mm. Geographic distribution: North, Mediterranean, and Adriatic Seas.

DIPLONEIS SMITHII Bréb.

Length, 0.0544 to 0.0612 mm; breadth, 0.029 to 0.0306; striæ, 5.5 to 6.5 in 0.01 mm. Our form is identical with Peragalli's figure.[4] Geographic distribution: North, Baltic, and Mediterranean Seas, Madagascar, Java, New Zealand, Campeachy Bay.

DIPLONEIS CHERSONENSIS Grun. Plate 1, fig. 18.

Length, 0.068 to 0.0884 mm; breadth, in the middle part, 0.012 to 0.0153; in the ends, 0.0238 to 0.0289; striæ, 9 to 14 in 0.01 mm. Geographic distribution: North and Mediterranean Seas, Ceylon, Philippines, China, Tahiti, West Indies.

[4] Diatom. de France pl. 19, fig. 29.

NAVICULA LIBER W. Sm. var. LINEARIS Grun. f. ORIENTALIS f. nov. Plate 1, fig. 21.

Length, 0.0748 mm; breadth, 0.0085; striæ, 11 in 0.01 mm. The typical form of *Navicula liber* var. *linearis* Grun. has 20 to 29 striæ in 0.01 mm and is found on the Atlantic coasts of Europe, Africa, and America; and in Ceylon, Honduras, and the Gulf of Mexico.

NAVICULA LIBER W. Sm. var. ELONGATA Grun. Plate 1, fig. 22.

A. Schmidt, Atlas Diatom. pl. 50, fig. 29.

Length, 0.0578 to 0.0748 mm; breadth, 0.0085 to 0.0102; striæ, 15 to 18 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Aylon, Florida.

NAVICULA LIBER W. Sm. var. GENUINA Cleve. Plate 1, fig. 19.

Length, 0.0884 mm; breadth, 0.0119 in the middle, 0.0187 in the ends; striæ, 18 to 20 in 0.01 mm.

NAVICULA LIBER f. SINICA f. nov. Plate 1, fig. 23.

Valve linear with convex margins and obtuse ends. Length, 0.119 mm; breadth, 0.0153. Axial area narrow, central area small. Striæ, 17 or 18 in 0.01 mm. This form is akin to *Navicula liber* var. *genuina* Cleve, between fig. 20 and fig. 37 of Schmidt's pl. 50, Atlas der Diatomaceen-Kunde.

NAVICULA HALOPHILA Grun. var. BREVIS var. nov. Plate 1, fig. 24.

Valves rhombic-lanceolate with obtuse ends. Length, 0.0487 mm; breadth, 0.0153; striæ, 18 in 0.01 mm, parallel. *Navicula halophila* is found in Sweden, England, Belgium, and France, in brackish water.

NAVICULA LIAOTUNGIENSIS sp. nov. Plate 1, fig. 26.

Valve narrow lanceolate with acute ends. Length, 0.182 mm; breadth, 0.021. Central nodule dilated to a stauros. Striæ, 14 or 15 in 0.01 mm. Puncta distinct. *Navicula liaotungiensis* is connected with *N. balearica* Cleve, known from the Balearic Islands.

NAVICULA GRANULATA BAIL. Plate 1, fig. 27.

Length, 0.0612 mm; breadth, 0.034; striæ, 8 or 9 in 0.01 mm. Geographic distribution: North Sea, Mediterranean Sea, Ceylon, Japan, Sydney.

NAVICULA CRUCICULA W. Sm. var. ORIENTALIS var. nov. Plate 1, fig. 16.

Valve elliptic with somewhat obtuse ends. Length, 0.0221 mm; breadth, 0.0102. Central nodule transversely dilated. Striæ,

16 or 17 in 0.01 mm. The median stronger and more distant, slightly radiate. Typical *N. crucicula* is found in the North, Baltic, and Adriatic Seas and the Atlantic Ocean.

NAVICULA (SCHIZONEMA) RAMOSISSIMA Ag. Plate 1, fig. 25.

Length, 0.056 mm; breadth, 0.0102; striæ, 10 or 11 in 0.01 mm. Geographic distribution: North Sea, Canada, Caspian Sea.

TRACHYNEIS ASPERA Ehrenb. var. VULGARIS Cleve.

Length, 0.107 mm; breadth, 0.0153; striæ, 8.5 in 0.01 mm. Geographic distribution: Arctic America, North Sea, New Zealand, Samoa, Java, Galapagos Islands.

TRACHYNEIS ASPERA Ehrenb var. ORIENTALIS var. nov. Plate 2, fig. 1.

Valve elliptic-lanceolate with obtuse or subrostrate ends. Length, 0.159 mm; breadth, 0.0255. Alveoli disposed in longitudinal and transverse rows; the former about 8.5 in 0.01 mm. This variety is closely connected with *T. aspera* and *T. johnsoniana*.

STAURONEIS PELLUCIDA Cleve var. ORIENTALIS var. nov. Plate 1, fig. 30.

Valve elliptic with broad, rounded ends. Length, 0.0272 mm; breadth, 0.0119. Central nodule transversely dilated to a stauros. Striæ, 15 in 0.01 mm. This form is connected with *S. pellucida* f. *mediterranea* Cleve, see Synopsis des Diatomees de Belgique, page 145.

PLEUROSYGMA NORMANII Ralfs. Plate 2, fig. 2.

Length, 0.156 mm; breadth, 0.027; striæ, 18 to 20 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Spitzbergen, Java, Sumatra, Atlantic Coast of North America.

PLEUROSYGMA FORMOSUM W. Sm. Plate 2, fig. 3.

Length, 0.425 mm; breadth, 0.066; striæ, 10 or 11 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Java, China, West Indies.

PLEUROSSYGMA ELONGATUM W. Sm. Plate 2, fig. 4.

Length, 0.153 mm; breadth, 0.0255; striæ, 15 in 0.01 mm. Geographic distribution: North, Mediterranean, Adriatic, Baltic, and Caspian Seas, Atlantic Coast of North America, Java, Sumatra, China.

PLEUROSYGMA BALTICUM Ehrenb. Plate 2, fig. 5.

Length, 0.24 mm; breadth, 0.0306; striæ, 11 or 12 in 0.01 mm. Geographic distribution: Baltic, North, Caspian, Mediterranean, Adriatic, and Red Seas, Java, Sumatra, Sandwich Islands, Samoa, Brazil, West Indies, Atlantic Coast of the United States.

PLEUROSYGMA DIMINUTUM Grun. Plate 2, fig. 6.

Length, 0.1139 mm; breadth, 0.0153; striæ, 18 to 20 in 0.01 mm. Geographic distribution: Adriatic and Mediterranean Seas.

PLEUROSYGMA SPECIOSUM Sm. Plate 2, fig. 7.

Length, 0.306 mm; breadth, 0.0289; striæ, longitudinal, 15; transverse, 15. Geographic distribution: North, Mediterranean, and Red Seas, Java, Sumatra, Labuan, China, Port Jackson, Barbados.

AMPHORA BIGIBBA Grun. Plate 1, fig. 20.

Length, 0.029 mm; breadth, 0.0076. Geographic distribution: Balearic Islands, Adriatic Sea, Japan, Chile, West Indies, Campeachy Bay.

AMPHORA DECUSSATA Grun. Plate 2, fig. 8.

Length, 0.1037 mm; breadth, 0.0187; striæ, 12 to 14 in 0.01 mm. Geographic distribution: Balearic Islands, Adriatic Sea, China, Honduras, Barbados.

AMPHORA RHOMBICA Kitton var. SINICA var. nov. Plate 2, fig. 9.

Valve cymbiform with long curved ends. Length, 0.1363 mm; breadth, 0.0238; striæ, 12 to 14 in 0.01 mm. The typical form *A. rhombica* is found in the Mediterranean Sea, Sumatra, the Philippines, and China.

AMPHORA OHGII sp. nov.[5] Plate 2, fig. 10.

Frustule in outline lunate with slightly rostrate ends. Length, 0.0289 mm; breadth, 0.01; striæ, 16 to 18 in 0.01 mm; punctate. Median line almost straight. Axial area distinct. This new species is remarkable for its lunate frustule. This species seems to me to be nearest akin to *A. minuta* Pant. or *A. szaboi* Pant. found fossil in brackish water in Hungary.

AMPHORA PROTEUS Greg. var. ROBUSTA var. nov.

Frustule somewhat rectangular, about 3.5 times longer than broad, with obtuse ends. Length, 0.0459 mm; breadth, 0.011 mm. Axial area narrow. Striæ, 12 to 13 in 0.01 mm.

AMPHORA PROTEUS Greg. Plate 2, fig. 12.

Length, 0.0289 mm; breadth, 0.006; striæ, 15 in 0.01 mm. Geographic distribution: North, Mediterranean, and Black Seas, China, Galapagos Islands, Campeachy Bay.

[5] Named in honour of Prof. J. Ohga, the well-known Japanese botanist in South Manchuria.

AMPHORA OSTREARIA Bréb. var. **TYPICA** Cleve. Plate 2, fig. 13.

Length, 0.0646 mm; breadth, 0.0153; striæ, 14 in 0.01 mm. Geographic distribution: Mediterranean and North Seas, Sumatra, China, Japan.

AMPHORA EXIGUA Greg. Plate 2, fig. 11.

Length, 0.0204 mm; breadth, 0.0025; striæ, 15 to 17 in 0.01 mm. Geographic distribution: Scotland, Arctic America, Adriatic Sea, Sandwich Islands, Tahiti, West Indies.

AMPHORA TERRORIS Ehrenb.

Length, 0.034 mm; breadth, 0.0042; striæ, 12 in 0.01 mm. Geographic distribution: Arctic America, Kara, North, and Mediterranean Seas, Gulf of Mexico.

AMPHORA ANGUSTA (Greg.) Cleve var. **TYPICA** Cleve.

Length, 0.0544 mm; breadth. 0.0085; striæ, 14 in 0.01 mm.

AMPHORA COSTATA W. Sm. Plate 2, fig. 15.

Length, 0.0357 to 0.0765 mm; breadth, 0.0085; striæ, 7.5 in 0.01 mm; puncta, 8 to 9 in 0.01 mm. Geographic distribution: North, Mediterranean, and Adriatic Seas, Sumatra, Campeachy Bay.

AMPHORA MARINA (W. Sm.) V. Heurck.

Length, 0.0323 mm; breadth, 0.0153; striæ, 18 in 0.01 mm. Geographic distribution: North Sea, China.

NITZSCHIA APICULATA Greg. var. **LIAOTUNGIENSIS** var. nov. Plate 2, fig. 16.

Valve round panduriform with acuminate ends. Length, 0.1115 mm; breadth, 0.0221; coarse striæ, 5.5 in 0.01 mm; fine striæ, 12 in 0.01 mm.

NITZSCHIA PUNCTATA Sm. var. **COARELATA** Grun. Plate 1, fig. 29.

Length, 0.0561 mm; breadth, 0.0119; striæ, 10 to 11 in 0.01 mm. North Sea.

NITZSCHIA PANDURIFORMIS Greg.

Length, 0.0374 mm; breadth, 0.0153; coarse striæ, 7 to 8; fine striæ, 15 in 0.01 mm.

NITZSCHIA PANDURIFORMIS Greg. var. **MINOR** Grun. Plate 1, fig. 28.

Length, 0.034 mm; breadth, 0.0136; striæ, 18 to 20 in 0.01 mm. North Sea.

NITZSCHIA INTERCEDENS Grun. Plate 2, fig. 18.

Length, 0.26 mm; breadth, 0.0136; coarse striæ, 6.5 in 0.01 mm. Mediterranean Sea.

NITZSCHIA SIGMA Kütz. var. **HABIRSHAWII** Febiger.

Peragallo, Diat. de France. pl. 74, fig. 5.

Length, 0.2732 mm; breadth, 0.009; coarse striæ, 5 to 6 in 0.01 mm; fine striæ, 24 in 0.01 mm.

NITZSCHIA SOCIALIS Greg.

Length, 0.0731 mm; breadth, 0.006; coarse lines, 7 in 0.01 mm; fine lines, 17 to 18 in 0.01 mm.

NITZSCHIA SPATHULATA Bréb. Plate 2, fig. 17.

Length, 0.102 mm; breadth, 0.0119; striæ, 4 in 0.01 mm.

NITZSCHIELLA LONGISSIMA Kütz. forma **TYPICA** V. Heurck. Plate 2, fig. 20.

Length, 0.306 mm; breadth, 0.0068; coarse striæ, 5 in 0.01 mm.

NITZSCHIELLA INCURVA Grun. Plate 2, fig. 19.

Length, 0.0782 mm; breadth, 0.0042; striæ, 14 to 15 in 0.01 mm. Black Sea.

ILLUSTRATIONS

Plate 1

FIG. 1. *Licmophora gracilis* Ehrenb.
2. *Campylodiscus intermedius* Grun.
3. *Surirella fluminensis* Grun.

FIGS. 4 and 5. *Surirella fastuosa* Ehrenb. var. *cuneata* A. Sm.

FIG. 6. *Campylodiscus samoensis* Grun.
7. *Surirella fastuosa* Ehrenb.
8. *Cocconeis scutellum* Ehrenb. var. *japonica* var. nov.
9. *Cocconeis scutellum* Ehrenb. var. *ornata* grun.
10. *Diploneis aestiva* Donk. forma β.
11. *Surirella liaotungiensis* sp. nov.
12. *Surirella liaotungiensis* sp. nov. var. *minuta* var. nov.
13. *Surirella gemma* Ehrenb.

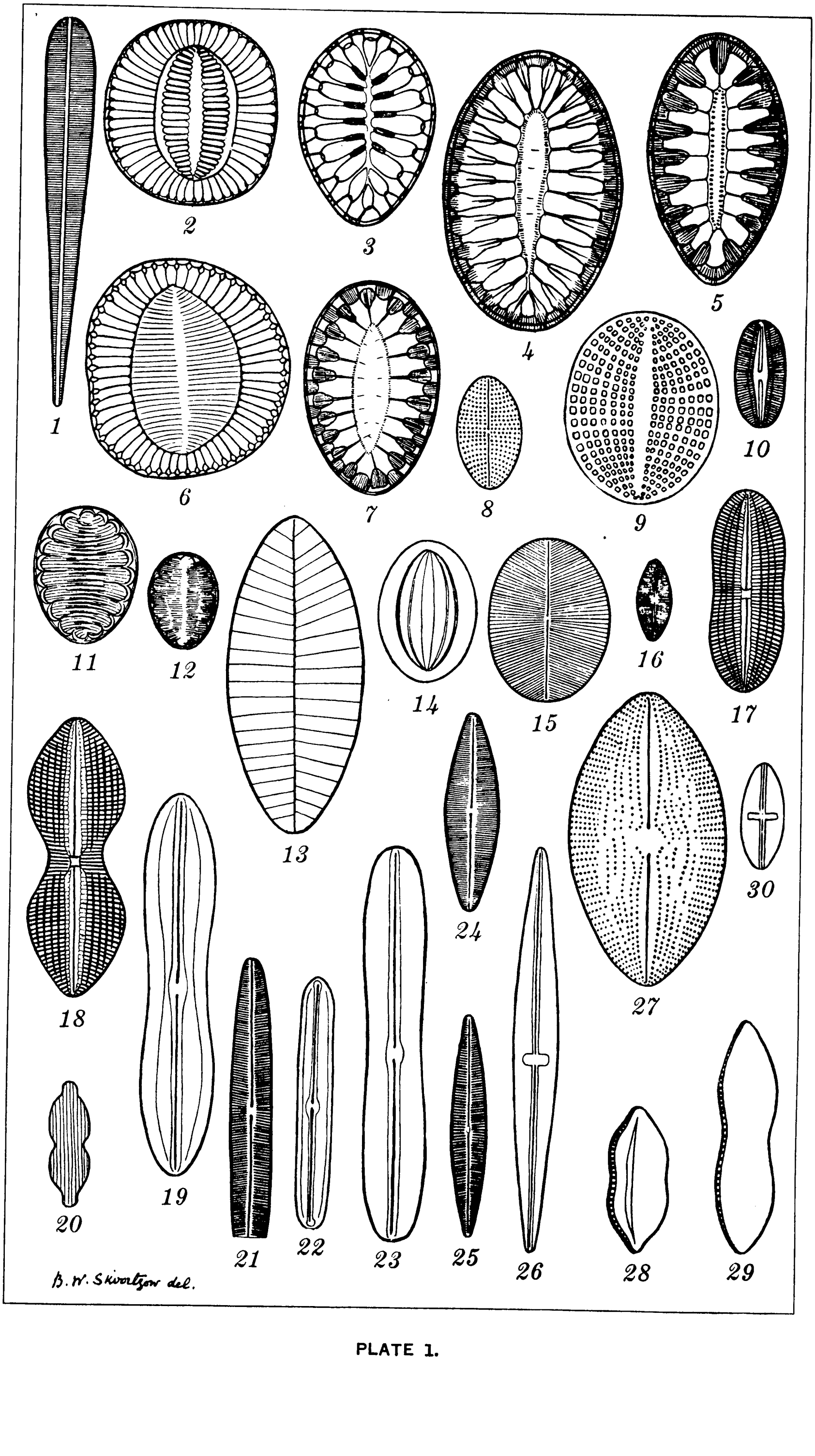
FIGS. 14 and 15. *Cocconeis pseudomarginata* Greg. var. *Formosa* var. nov.

FIG. 16. *Navicula crucicula* W. Sm. var. orientalis var. nov.
17. *Diploneis lineata* Donk.
18. *Diploneis chersonensis* Grun.
19. *Navicula liber* W. Sm. var. *genuina* Cleve.
20. *Amphora bigibba* Grun.
21. *Navicula liber* W. Sm. var. *linearis* Grun. f. *orientalis* f. nov.
22. *Navicula liber* W. Sm. var. *elongata* Grun.
23. *Navicula liber* W. Sm. var. *genuina* Cleve f. *sinica* f. nov.
24. *Navicula halophila* Grun. var. *brevis* var. nov.
25. *Navicula (Schizonema) ramosissima* Ag.
26. *Navicula liaotungiensis* sp. nov.
27. *Navicula granulata* Bail.
28. *Nitzschia panduriformis* Greg. var. *minor* Grun.
29. *Nitzschia punctata* Sm. var. *coarctata* Grun.
30. *Stauroneis pellucida* Cleve var. *orientalis* var. nov.

Plate 2

FIG. 1. *Trachyneis aspera* Ehrenb. var. *orientalis* var. nov.
2. *Pleurosygma normanii* Ralfs.
3. *Pleurosygma formosum* W. Sm.
4. *Pleurosygma elongatum* W. Sm.
5. *Pleurosygma balticum* Ehrenb.
6. *Pleurosygma diminutum* Grun.
7. *Pleurosygma speciosum* Sm.
8. *Amphora decussata* Grun.
9. *Amphora rhombica* Kitton var. *sinica* var. nov.
10. *Amphora ohgii* sp. nov.

FIG. 11. *Amphora exigua* Greg.
12. *Amphora proteus* Greg.
13. *Amphora ostrearia* Bréb. var. *typica* Cleve.
14. *Triceratium favus* Ehrenb.
15. *Amphora costata* W. Sm.
16. *Nitzschia apiculata* Greg. var. *liaotungiensis* var. nov.
17. *Nitzschia spathulata* Bréb.
18. *Nitzschia intercedens* Grun.
19. *Nitzschiella incurra* Grun.
20. *Nitzschiella longissima* Kütz. f. *typica* V. Heurck.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B. W. Skvortzow del.

PLATE 1.

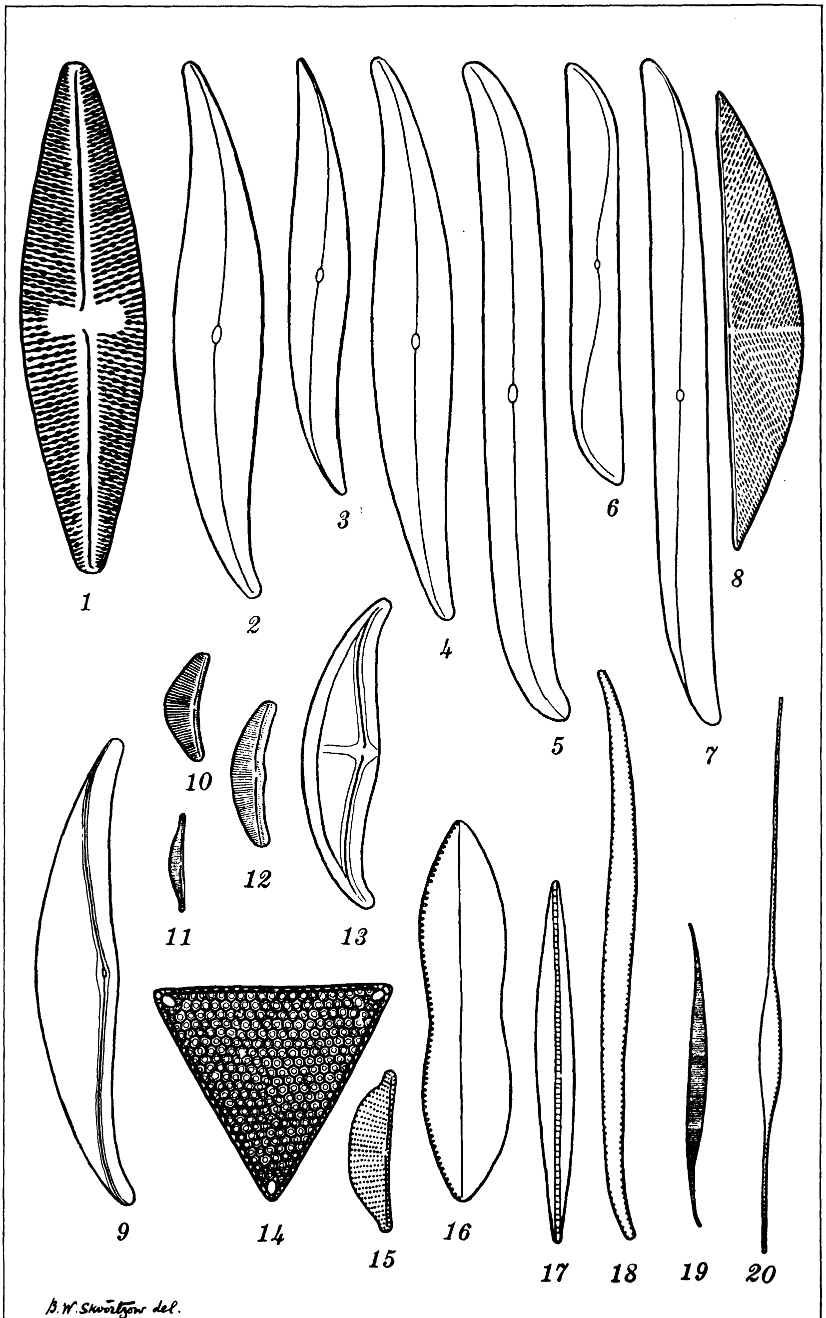

PLATE 2.

THE BUCCOPHARYNGEAL ARMATURE OF PHILIPPINE ANOPHELINES

By C. MANALANG

Of the Philippine Health Service, Manila

FOUR PLATES

Sinton and Covell [1] and later Barraud and Covell [2] dissected the buccopharyngeal armature of the females of eighty-six species of anophelines. The latter workers arranged the members of the genus *Anopheles* into five classes according to the character of the buccopharyngeal armature as follows: Class A, armature absent; Class B, armature consists of a single row of large separate pectenate teeth, 8 to 10 in number with two exceptions, *A. aureosquaminger* and *A. watsoni,* which have 12 to 14; Class C, armature of two rows of teeth very markedly curved so that their ends are directed forwards. Posterior hard palate cobble-stoned; Class D, armature of a double row of teeth without deep-set roots with 12 to 14 teeth in each row except in *A. ramsayi* which has 8; Class E, armature of a double row of teeth there being 18 to 26 in each row except *A. ludlowii* and *A. parangensis* which have 14 to 16. The teeth have long, deep-set, narrow bases, and their line of origin forms a strongly pronounced curve.

The present paper is a study of the buccopharyngeal armature of the commonest species of Philippine anophelines; namely, *Anopheles minimus* Theobald, *A. ludlowii* Theobald, *A. subpictus* Grassi, *A. vagus* Donitz, *A. kochi* Donitz, *A. tesselatus* Theobald, *A. philippinensis* Ludlow, *A. fuliginosus* Giles, *A. hyrcanus* Wiedemann, *A. barbirostris* Van der Wulp, *A. maculatus* Theobald, *A. karwari* James, and an unnamed one probably a new species.

TECHNIC

The head is macerrated in 10 to 15 per cent caustic potash aided by a few minutes boiling. As soon as the eyes are trans-

[1] Indian Journ. Med. Research 15 No. 2 (1927).

[2] Indian Journ. Med. Research 15 No. 3 (1928).

parent (Plate 1, fig. 1) the specimen is washed in water and dissected in a drop of water on a slide under a dissecting microscope. The entire buccopharyngeal skeleton with the clypeus and both epipharynx and hypopharynx can be isolated with very little difficulty, by placing a needle at the occiput and pulling the skeleton by forward traction with another needle on the clypeus. The excess of water is drained off with filter paper. For observation place the specimen, by the use of needles, in a dorsoventral position under the dissecting microscope; and allow it to dry slowly over a small alcohol flame. The angle at the buccopharyngeal junction and the prominence and weight of the clypeus (Plate 1, fig. 2) often cause the specimen to fall on the side when applying the cover glass. This may be avoided by carefully breaking off the clypeus and slightly crushing the pharyngeal bulb dorsoventrally. A small amount of albumen fixative added to the drop of water while dissecting helps in keeping the specimen in position while it is drying. The specimen when thoroughly dry is mounted in Canada balsam. Air bubbles are frequently captured in the buccopharyngeal cavity and obliterate the armature. These are removed by heating the slide over the flame.

FINDINGS

The results of the present work on twelve of the commoner anopheline species in the Philippines show them to belong in either of the four classes A, B, D, and E but none in Class C. The unnamed species belongs to class B. It has a single row of eight large separate pectenate teeth (Plate 4, fig. 16). We have been unable to identify the name of this mosquito among those described in the Orient in the limited literature available. For this reason a brief description of the larva and adult female is here given.

LARVA

Habitat.—Eddies on sides of streams in Kolambugan, Lanao, Mindanao; associated with *A. minimus* and of the same size. Recognized by white bands on the anterior half of the thorax, and on second, fifth, and last two abdominal segments.

Head.—Inner anterior clypeal hair stout and minutely frayed; outer anterior clypeal hair about one-fifth as long as the inner; closely approximated to it, with three stout branches. Preantennal hair with four to five branches and about as widely approximated as the inner anterior clypeal hairs. Vertical hairs basally biped; and transutural hair with three branches.

Thorax.—Anterior half conspicuously light in color, and dark posteriorly. Inner anterior submedian thoracic hair heavily branched as in *Anopheles minimus* Theobald, about one-half as long as the central and lateral submedian thoracic hairs; palmate hair very rudimentary.

Abdomen.—Second, fifth, and the last two abdominal segments conspicuously light in color which does not disappear in 10 per cent formalin as preservative. Palmate hair of first and second abdominal segments poorly developed. Palmate hairs 18 to 22 leaflets; lanceolate in shape and not filamentous distally. Antepalmate hair simple.

ADULT FEMALE, HEAD; ANTENNÆ MISSING

Probocis.—Labella brown followed by a narrow black band. Then a white band of the same width and black shaft.

Palpi.—With five white bands, the apical yellowish, the second white band from the apical very broad and separated from it by a narrow black band. Two narrow black bands separated by a narrow white follow the second white band. The fourth and fifth white bands are separated by a broad black band.

Thorax.—Dorsum silvery white with three faint narrow brown lines running anteroposteriorly and two black eye spots just anterior to the middle prominence. Halteres covered with white scales.

Wings.—The costa with eight black spots, four of which involve the first vein. Three spots are large, one near the apex, one at the middle being the largest and one one-third the distance from the base.

Abdomen.—Segments with lateral tufts of hair and scales except the first and second segments.

Legs.—Femora, tibia, and first tarsal markedly spotted with narrow white bands at the tarsal articulations.

COMMENTS

Barraud and Covell's lists of species under each class of buccopharyngeal armature contain all the Philippine species studied except the list under Class C and the results of the present study confirm their observations except in the case of *A. ludlowii*. They include this species in Class E, but specify that it has only 14 to 16 teeth to each row instead of 18 to 26. The Philippine *A. ludlowii*, however, seems to be different. We recognize *A. ludlowii* by the palpal distal black band being equal in width to or one-half or more of the apical white band, by the *A. rossii*

type of wing markings; and with spotted femora and tibia. We seem to have two varieties of *A. ludlowii;* one variety, a small one with spotted legs the distal black palpal band equal to the apical white, and with 16 teeth; and a larger variety also with spotted legs but the distal black palpal band narrower than the apical white with 24 to 26 teeth like those found in *A. subpictus* and *A. vagus.* The spotting of the legs is our main criterion in differentiating *A. ludlowii* from what we call *A. subpictus.* If this is adhered to, then we have two varieties of *A. ludlowii.* If the number of teeth in the buccopharyngeal armature is to be followed, however, then we have two varieties of *A. subpictus,* one with spotted legs and another without.

Further study in this respect is called for, because we have no direct evidence against *A. ludlowii* as a malaria transmitter in the Philippines, although it is a confirmed vector in other countries. A study of the armature of the *A. ludlowii-vagus* group in other countries is also indicated with a view of standardizing their nomenclature because there seems to be a confusion of names in this group.

ILLUSTRATIONS

[Photomicrographs by C. M. Urbino, Malaria Control Section, Philippine Health Service.]

PLATE 1

FIG. 1. Cleared head of *A. minimus*, dorsoventral view; × 100.

2. Buccopharyngeal skeleton of *A. subpictus*, lateral view; about × 100.
3. Buccopharyngeal junction of *A. hyrcanus*, dorsoventral view; about × 330. Class A (no teeth).
4. Buccopharyngeal junction of *A. barbirostris*, dorsoventral view; × 330. Class A (no teeth).

PLATE 2

FIG. 5. Buccopharyngeal junction of *A. kochi* with armature of large separate pectenate teeth, dorsoventral; × 330. Class B.

6. Buccopharyngeal armature of *A. tesselatus*, dorsoventral; × 330. Class B.
7. Buccopharyngeal armature of *A. maculatus*, dorsoventral; × 330. Class D.
8. Buccopharyngeal armature of *A. fuliginosus*, dorsoventral; × 330. Class D.

PLATE 3

FIG. 9. Buccopharyngeal armature of *A. philippinensis*, dorsoventral; × 330. Class D.

10. Buccopharyngeal armature of *A. minimus*, dorsoventral; × 330. Class D.
11. Buccopharyngeal armature of *A. karwari*, dorsoventral; × 330. Class D.
12. Buccopharyngeal armature of *A. ludlowii*, palpal apical black band narrower than the apical white band; 22 teeth visible; dorsoventral; × 330. Class E.

PLATE 4

FIG. 13. Buccopharyngeal armature of *A. ludlowii*; palpal apical black band equal in width to the apical white band; 14 teeth visible; dorsoventral; × 330. Class E.

14. Buccopharyngeal armature of *A. subpictus*, dorsoventral; × 330. Class E.
15. Buccopharyngeal armature of *A. vagus*, dorsoventral; × 330. Class E.
16. Buccopharyngeal armature of the Kolambugan species (undetermined) with large separate pectenate teeth, dorsoventral; × 330. Class B.

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PLATE 1.

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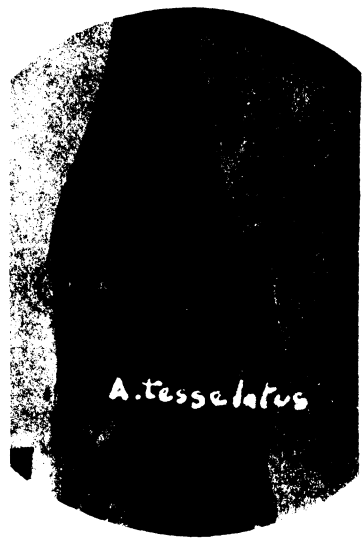

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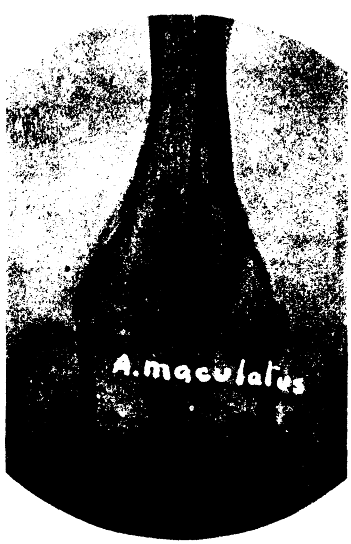

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PLATE 2.

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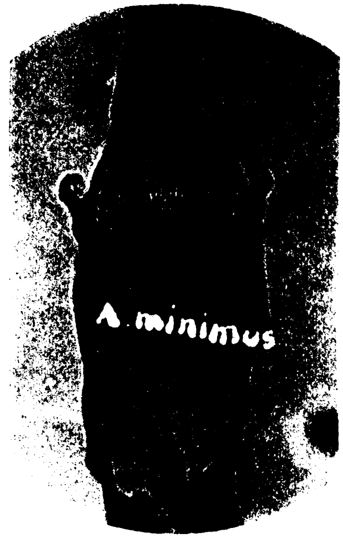

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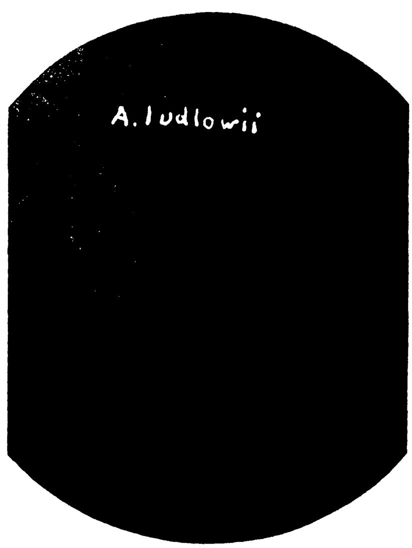

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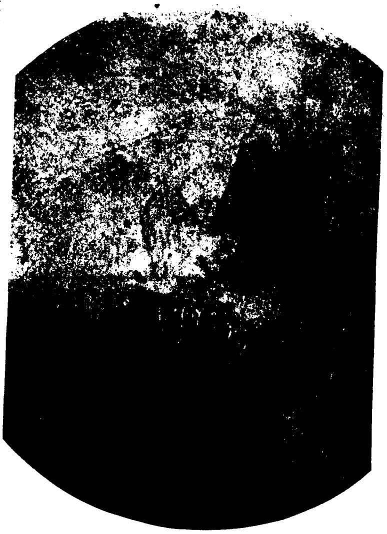
PLATE 3.



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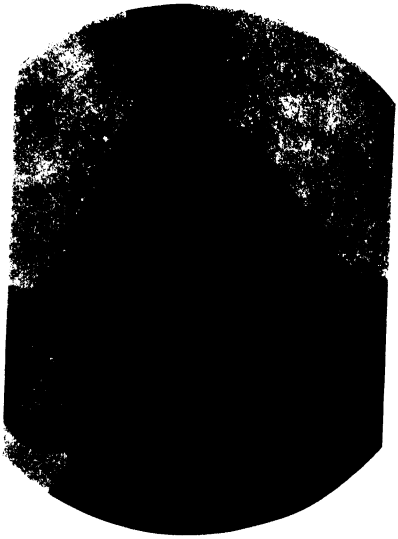

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PLATE 4.

REPORT OF A CASE OF RHINOSPORIDIOSIS

By C. MANALANG

Of the Philippine Health Service, Manila

THREE PLATES

Castellani and Chalmers [1] define rhinosporidiosis as a "chronic infection caused by *Rhinosporidium seeberi* Wernicke, 1900, and characterized by the production of polypi on the mucous membrane and papillomata on cutaneous surfaces."

According to these authors the disease was first recognized by Malbran in 1892 in South America, and by Seeber in 1896 in Buenos Aires. Wernicke named the parasite *Coccidium seeberi* in 1900. Kenealy in 1894 found a pedunculated, raspberry-like body on the nasal septum of an Indian in Calcutta and reported it in 1903 as having peculiar bodies embedded in the tissues. Minchin and Fantham called these bodies *Rhinosporidium kinealyi.* Other reports were those of Nair on the west coast of India in 1905, Beattie in 1906 in Cochin, Castellani and Chalmers in 1910, and Cheliah in 1918—the last two from Ceylon. According to Beattie [2] the disease is very frequent among the natives of the state of Cochin. Blanchard studied a case from Argentine. Manson-Bahr [3] mentions that the parasite has also been recorded in the United States.

As described by Castellani and Chalmers the parasite in sections consists of cysts which may be oval, round, tubular, branched or irregular bodies lying mostly below the epithelium. The cyst wall is thin and has either an opening or a conical elevation at one point. The smaller cysts contain undifferentiated protoplasm with a nucleus, the larger ones with one or more definite chromatic masses while the well-developed cysts are filled with matured pansporoblasts located in the center with young ones in the periphery. The matured pansporoblast contains sixteen spores and is liberated by rupture of the cyst wall. The cysts vary in diameter from 10 to 30 microns when young and from 200 to 300 microns when mature.

[1] Manual of Tropical Medicine 3d ed.
[2] Brumpt, Nociones de Parasitologica 96.
[3] Manson's Tropical Diseases 8th ed. (1925) 625.

The parasite was originally considered a protozoan allied to *Coccidium,* but Manson-Bahr cites Asworth (1923) as having shown the organism as probably a yeast or phycomycete. This view is also held by Chandler.[4] Ashworth had only partial success in cultivating the parasite, and the spores multiplied slowly on Saboraud's medium.

According to Rivas[5] the life history of this parasite is apparently very simple, and he describes the asexual reproduction as follows:

> On entering the host the young trophozoite becomes encysted, multiplies and gives rise to a multinucleated mass of protoplasm that divides forming several sporoblasts (pansporoblasts) containing the merozoites or spores. When the cyst ruptures, these spores are set free, invade the surrounding tissues, grow into trophozoites, and the cycle is repeated. Sexual reproduction is not known.

The infection is probably acquired directly or indirectly through abrasions in the mucosa.

Lesions.—The parasite is supposed to produce polyps in the nose or ears which often recur after removal. Castellani and Chalmers mention the production of papillomata on cutaneous surfaces, for example the penis, while Byam and Archibald[6] state that the parasite, though rarely, also attacks the conjunctiva and skin of the eyelids, where it also forms polypoid growths. The appearance of the growth is said to be distinctive in that the edges are semitransparent with a band of fibrous tissue running through the middle. According to Chandlers it has been suggested that polypi in the nose due to this parasite may have the same influence on the intellect as the nonparasitic ones. According to Rivas, "the main lesion consists of proliferation of the nasal mucosa and submucosa caused by the irritation set up by the parasite." Castellani and Chalmers suspect that the infections may be give rise to a septicæmic or generalized infection in which case the prognosis would be bad.

Treatment.—According to Manson-Bahr, the treatment "consists in removing the polypi from the nares by means of a wire snare. Medical treatment would not appear to be indicated, although Wright has reported that the tumors disappear after

[4] Animal Parasities and Human Disease 3d ed. John Wiley & Sons (1926) 173.

[5] Human Parasitology. W. B. Saunders (1920) 150.

[6] Practice of Medicine in the Tropics. Oxford Medical Publication 3 (1923) 2293.

intravenous injections of tartar emetic." Castellani and Chalmers recommend cauterization of the base after removal of the growth.

CASE REPORT

The material for this report consists of fragments of white, friable, papillomatous tissue preserved in 10 per cent formalin and labelled "nasal polyps." The polyps were sent by Dr. S. Y. Orosa, of the Philippine Health Service Provincial Hospital, Occidental Negros, with a note that they were removed from a Filipino boy of 7 years, residing in the Municipality of Talisay. No other data were furnished.

Pieces of tissues were embedded in parrafin, sectioned, and stained with hæmatoxylin-eosin. Histologic examination (Plate 1, fig. 1) showed numerous various-sized spherical cysts with distinct wall, widely distributed throughout the tissue including a few in the mucous lining (Plate 1, fig. 2). The cysts varied from 10 to 200 microns in diameter. Some of the cysts were oval, while few were tubular, crescent-shaped, or irregular (Plate 1, fig. 1). These different shapes were probably mechanical, for the cysts all appeared spherical in potash preparation (Plate 2, fig. 3). Most of the cysts contained granular or hyalinelike material, often vacuolated, and with occasional nuclear bodies. Few of the smaller cysts contain a dark-staining substance, as if indicating a tendency to calcification (Plate 2, fig. 4). Few eosinophiles were seen in some areas of the myxomatous tissue surrounding these cysts. Occasional groups of round cells with polynuclears were seen, as if tending to miliary-abscess formation (Plate 3, fig. 5). No necrotic nor fibrosed areas were observed except the centrally located fibrous core of the growth. The bulk of the growth is myxomatous tissue with some thickening of the mucous covering. The tissue was not particularly vascular. Teased portions of the bits of tissue in formalin examined under a cover slip or, better still, bits of tissues when boiled for a few minutes in 10 to 15 per cent potassium hydrate solution showed the nature of these cysts better than sections (Plate 2, fig. 3). With this preparation many, small, scattered, refractile bodies (pansporoblasts) of about 8 microns in diameter, containing half a dozen or more refractile spores, were seen. Large matured cysts were filled with pansporoblasts, which poured out in large numbers when the cyst wall was broken by pressure on the cover slip (Plate 3, fig. 6).

The literature consulted seems to be unanimous that the parasite produces polyps and papillomata rather than an accidental infection of an already existing growth, although it would appear that there should be more tissue reaction unless the tumor formation is the reaction itself. The extensive distribution of the cysts below the mucosa and the presence of only a few cysts in the mucosa certainly favor the etiologic relationship of the parasite with the disease. It cannot be determined if the parasite in the present case is identical with *Rhinosporidium seeberi* Wernicke or with *Rhinosporidium kinealyi* Minchin and Fantham, but the material as described and illustrated leaves very little doubt as to its nature.

Whether or not the infection is common in the Philippines, can be shown only by a systematic examination of tissues removed from children in various parts of the Islands. As far as I can find, this is the first reported case of rhinosporidiosis in the Philippines.

ILLUSTRATIONS

[Photomicrographs by E. Cortes, Bureau of Science.]

Sections of a polyp from a case of rhinosporidiosis in the Philippine Islands

PLATE 1

FIG. 1. Section of the polyp showing thickened mucosa at *a*, with a few round cells at *b*; *c* and *d* indicate crescent and irregularly shaped cysts, respectively. × 100.

2. A portion of the polyp showing two cysts, *a* and *b*, in the mucosa. The other cysts are in the submucosa. × 400.

PLATE 2

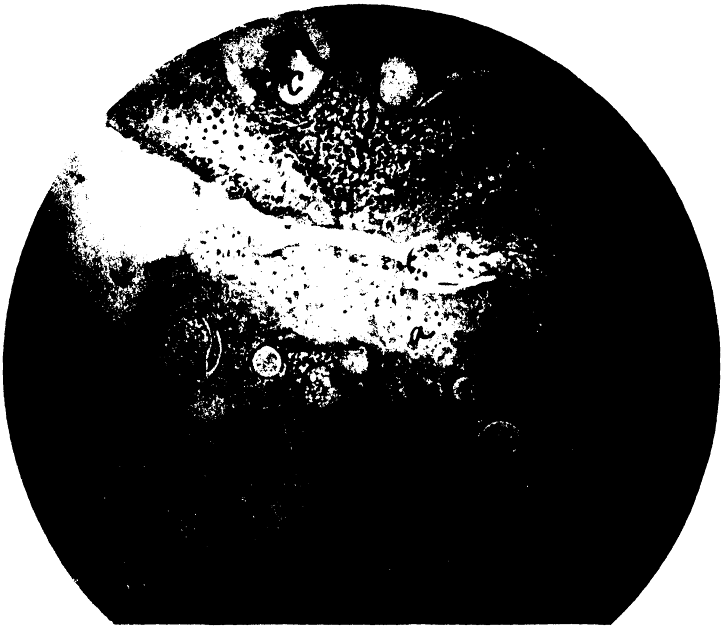
FIG. 3. Potassium hydrate preparation showing all stages of the cysts. The cysts are spherical in shape.

4. A portion of the polyp showing about a dozen small cysts, *x*, which stained dark as if calcified. × 100.

PLATE 3

FIG. 5. A portion of the polyp with apparently beginning milliary abscess. × 100.

6. Teased preparation showing a matured cyst ruptured by pressure on the cover glass. The cyst is filled and surrounded by a large number of young and full-grown pansporoblasts, the former occupying the upper half of the cyst. × 140.



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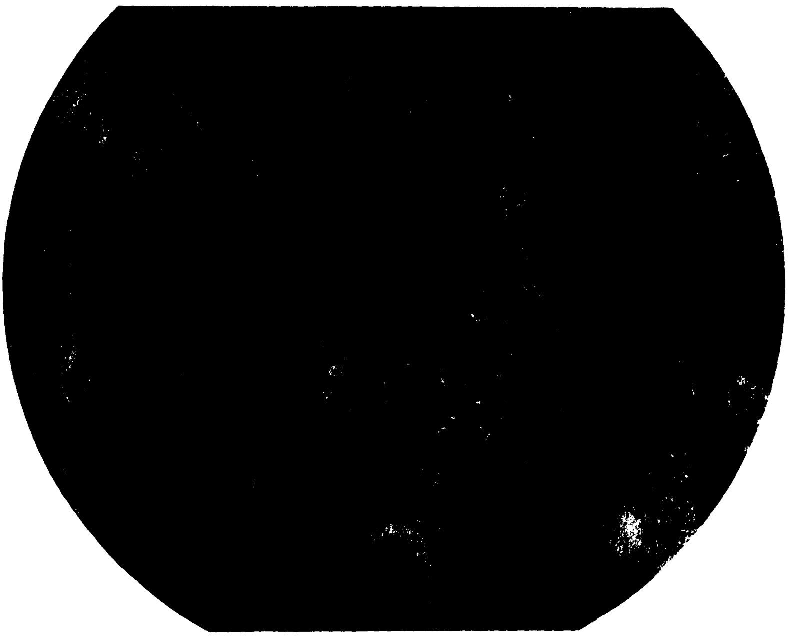

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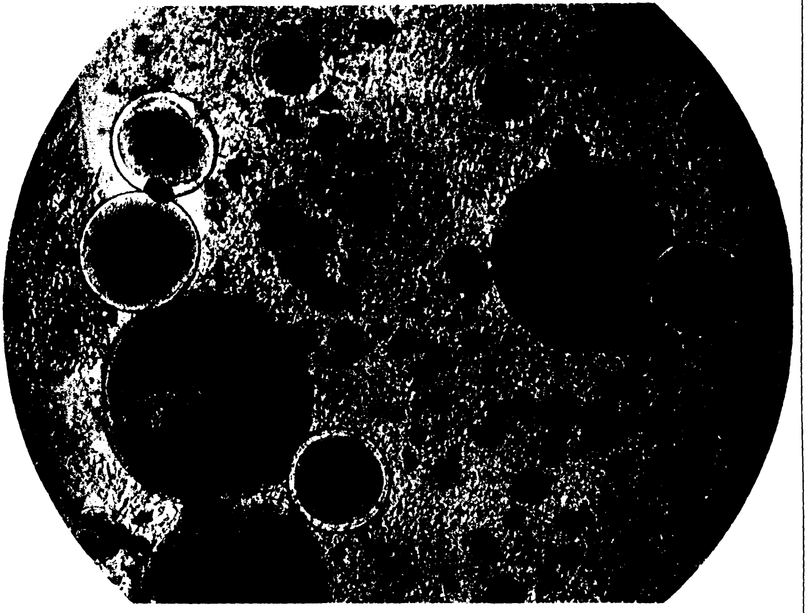
PLATE 1.



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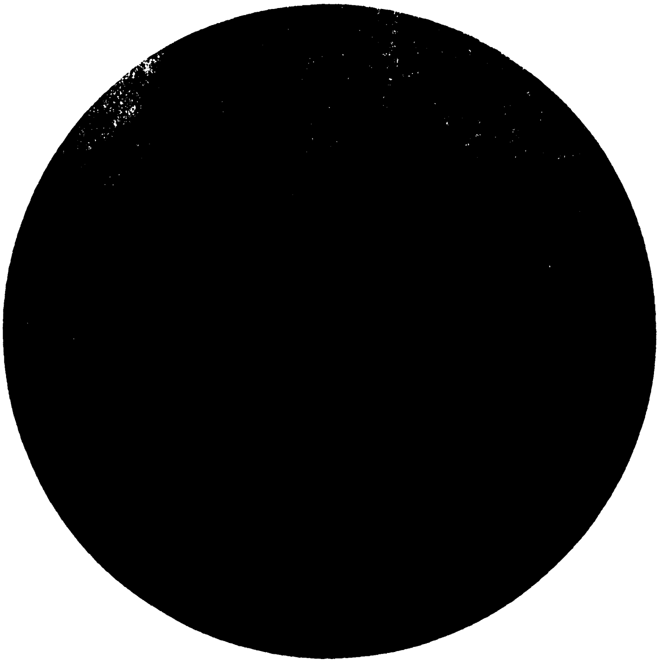

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PLATE 2.

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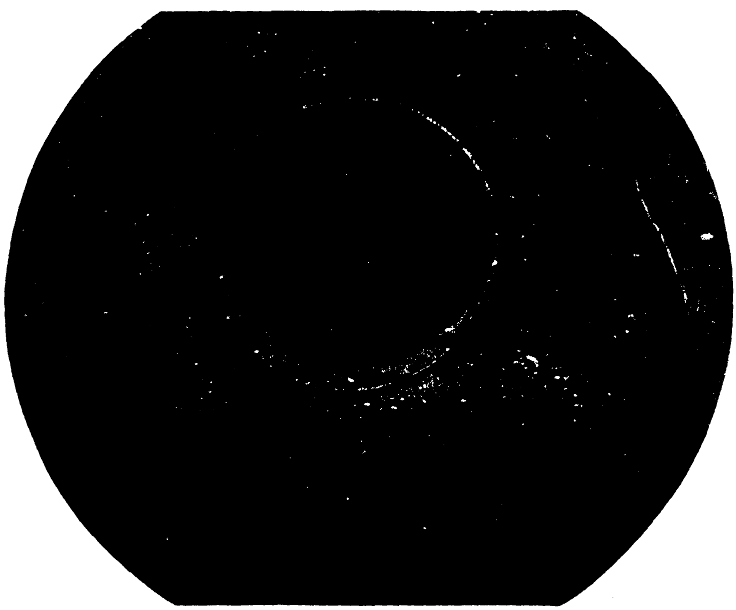

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PLATE 3.

PARADISTOMUM GREGARINUM, A NEW NAME FOR THE TREMATODE PARADISTOMUM MAGNUM

By MARCOS A. TUBANGUI

Of the University of the Philippines, Los Baños

In a paper on the trematode parasites of Philippine vertebrates [1] I described a trematode from the gall bladder of a lizard under the name *Paradistomum magnum.* Dr. Albert Hassall, of the United States Bureau of Animal Industry, has kindly called my attention to the fact that this name is preoccupied by *Paradistomum magnum* Travassos, 1920, for which reason I propose the new name *Paradistomum gregarinum* to replace *Paradistomum magnum* Tubangui, 1928.

I wish also to call attention to the following errata to the same paper:

Page 353, lines 6 and 13 from the top, for *Stepoda* read *Stegopa.*

Page 363, line 9 from the top, *for* Plate 5, *read* Plate 4; line 14 from the bottom, *for* fig. 3, *read* fig. 4.

Page 364, line 21 from the bottom, *for* fig. 4, *read* fig. 3.

Page 367, line 11 from the top *for* Plate 7, fig. 2, *read* Plate 5, fig. 3.

Page 371, under Plate 4, Fig. 3 *should be* Fig. 4 *and* Fig. 4 *should be* Fig. 3.

[1] Philip. Journ. Sci. **36** (1928) 351–371.

CHAULMOOGRYL AMINO PHENOLS AND CHAULMOOGRYL BENZYLAMINE

By IRENE DE SANTOS and AUGUSTUS P. WEST
Of the Bureau of Science, Manila

Various derivatives of chaulmoogric acid, such as esters, have been made from chaulmoogra oil.[1] In the present investigation, a few chaulmoogryl amino phenols and chaulmoogryl benzylamine were prepared. The method of preparation consisted in treating the acid amide of chaulmoogric acid with the chlor phenols or benzyl chloride in the presence of metallic copper (Goldberg's reaction).[2] The results seem to indicate that these compounds may be prepared rather easily though these reactions take place somewhat slowly. The new compounds prepared in this research will be tested for their therapeutic value. In order to check the formulas of these compounds, the nitrogen content was determined. A modification of Meulen's catalytic method [3] was employed for making the nitrogen analyses.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was kindly presented to us by Dr. H. I. Cole, of the Philippine Bureau of Health, and was shipped directly to us from the Culion Leper

[1] Power, F. B., and F. H. Gornall, Journ. Chem. Soc. Trans. **85** (1904) 838 and 851.—Power, F. B., and M. Barrowcliff, Journ. Chem. Soc. Trans. **91**, 1, (1907) 557.—Shriner, R. L., and Roger Adams, Journ. Am. Chem. Soc. 47 (1925) 2727.—Perkins, G. A., Philip. Journ. Sci. 24 (1924) 621.—Perkins, G. A. and A. O. Cruz, Journ. Am. Chem. Soc. **49** (1927) 1070.—Perkins, G. A., Journ. Am. Chem. Soc. **48** (1926) 1714.—Van Dyke, R. H., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 2393.—Sacks. J., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 2395.—Dean, A. L., R. Wrenshall, and G. Fujimoto, Journ. Am. Chem. Soc. **47** (1925) 403.—Noller, C. R., and Roger Adams, Journ. Am. Chem. Soc. **48** (1926) 1080.—Herrera-Batteke. P. P., and A. P. West, Philip. Journ. Sci. **31** (1926) 161.—Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265.—Santiago, S., and A. P. West, Philip. Journ. Sci. **35** (1928) 405.— de Santos, I., and A. P. West, Philip. Journ. Sci. (in press).

[2] Goldberg, I., Ber. Deut. Chem. Gesell. **39** (1906) 1691.

[3] Smith, F. L., and A. P. West, Philip. Journ. Sci. **31** (1926) 265.

Colony. The oil was prepared from the seeds of *Hydnocarpus alcalæ* C. de Candolle.

The chaulmoogric acid and the acid amide of chaulmoogric acid were prepared according to the procedure used by Santiago and West.[4] Chaulmoogra oil (600 grams) was saponified with alcoholic potassium hydroxide (200 grams dissolved in 80 cubic centimeters of water and 800 cubic centimeters of aldehyde-free alcohol). The mixture was heated (reflux) on a water bath for about four hours, after which the excess alcohol was removed by distillation. The residual soaps were decomposed with dilute sulphuric acid (1: 3) and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resins were separated from the acid by filtering. The gasoline was then removed by distillation and the residue crystallized several times from alcohol (95 per cent). The melting point of the chaulmoogric acid was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid with phosporus trichloride. The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid was allowed to drop slowly into cold concentrated ammonia. The precipitated amide was washed with water and dried. The amide was then dissolved in methyl alcohol, the solution decolorized with bone black, and allowed to crystallize. The amide was then recrystallized from xylene and finally from absolute alcohol. The melting point was 104 to 105° C.

CHAULMOOGRYL O-AMINO PHENOL

$$\left.\begin{array}{l} CH=CH \\ | \\ CH_2-CH_2 \end{array}\right\rangle CH(CH_2)_{12}CONH-O-C_6H_4OH$$

This compound was prepared by treating the acid amide of chaulmoogric acid with *o*-chlor phenol in the presence of powdered metallic copper which was prepared by reducing powdered black copper oxide in a current of hydrogen. Ten grams of

[4] Philip. Journ. Sci. 33 (1927) 265.

chaulmoogramide were placed in a round flask, and 0.2 gram of powdered copper was added to the amide. Ortho chlor phenol (6.3 cubic centimeters) and 5 grams of powdered fused sodium acetate were added to the mixture. The use of the sodium acetate was to neutralize the hydrochloric acid evolved during the reaction. The flask was then connected to a reflux condenser and heated in a Crisco oil bath to a temperature of about 125° C. until no more acid vapors were evolved, which required about three days. The black solid reaction product was dissolved in methyl alcohol and filtered to eliminate the copper catalyst. The solution was decolorized with animal charcoal and allowed to crystallize. The product was then crystalized three more times from methyl alcohol. White crystals melting at 104.9 to 105.9° C. were obtained. The chaulmoogryl *o*-amino phenol was found to be soluble in the common organic solvents. The yield was about 15 per cent.

Analysis:

	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	3.94

CHAULMOOGRYL M-AMINO PHENOL

$$\left.\begin{array}{l} CH=CH \\ \mid \\ CH_2-CH_2 \end{array}\right\rangle CH(CH_2)_{12}CONH-M-C_6H_4OH$$

This compound was prepared by treating the acid amide of chaulmoogric acid with *m*-chlor phenol in the presence of copper. Chaulmoogramide (15 grams) was placed in a round flask and to this were added 9.4 cubic centimeters of *m*-chlor phenol, 7.5 grams of anhydrous sodium acetate, 0.2 gram of powdered copper, and 120 cubic centimeters of nitrobenzene. The mixture was heated (reflux) over a wire gauze until no more acid vapors were evolved. The reaction product, which was a black mass, was dissolved in ethyl alcohol and filtered to remove the copper catalyst. The alcoholic solution was then distilled in a current of alcohol vapor in order to remove most of the nitrobenzene. The alcoholic solution of the reaction product was diluted somewhat with alcohol, decolorized with animal charcoal, and allowed to crystallize. After recrystallizing in methyl alcohol, white crystals melting at 105.9 to 108° C. were obtained. The yield was about 5 per cent. The compound is soluble in the common

organic solvents, with the exception of petroleum ether in which it is only slightly soluble.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	3.93

CHAULMOOGRYL P-AMINO PHENOL

$$\begin{array}{l} CH = CH \diagdown \\ | \qquad\qquad\quad > CH(CH_2)_{12}CONH—P—C_6H_4OH \\ CH_2—CH_2 \diagup \end{array}$$

The substance was made by the interaction of chaulmoogramide, *p*-chlor phenol, sodium acetate, and copper. Chaulmoogramide (10 grams) was placed in a round flask and treated with 7.82 grams of *p*-chlor phenol, 5 grams of anhydrous sodium acetate, and 0.2 gram of powdered copper. The mixture was heated (reflux) at a temperature of about 120° C. until no more acid vapors were evolved, which required about two days. The reaction product was dissolved in methyl alcohol and filtered to remove the catalyst. The solution was decolorized with animal charcoal and allowed to crystallize. After recrystallizing from methyl alcohol, white crystals melting at 97.8 to 101.9° C. were obtained. The yield was about 15 per cent. The compound is soluble in the common organic solvents but only slightly soluble in petroleum ether and carbon bisulphide.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	4.08

CHAULMOOGRYL BENZYLAMINE

$$\begin{array}{l} CH = CH \diagdown \\ | \qquad\qquad\quad > CH(CH_2)_{12}CONHCH_2C_6H_5 \\ CH_2—CH_2 \diagup \end{array}$$

The chaulmoogryl benzylamine was obtained by heating a mixture consisting of 12 grams of chaulmoogramide, 8.38 cubic centimeters of benzyl chloride, 5 grams of anhydrous, fused sodium acetate, and 0.2 gram of powdered copper. The procedure was similar to that used in making the other chaulmoogryl derivatives. The crude reaction product was dissolved in methyl alcohol and filtered to remove the catalyst. The alcoholic solution was then decolorized with animal charcoal to which Kieselguhr was added in order to eliminate colloidal

substances. Crystals obtained from the alcoholic solution were recrystallized from methyl alcohol. The melting point was 92.7 to 95.8° C. The yield was about 22 per cent. The compound was soluble in most of the common organic solvents but only slightly soluble in carbon tetrachloride, xylene, and petroleum ether.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{25}H_{39}ON$	3.79
Found	3.83

SUMMARY

Four new chaulmoogric compounds were prepared in this investigation. They are chaulmoogryl *o*-amino phenol, chaulmoogryl *m*-amino phenol, chaulmoogryl *p*-amino phenol, and chaulmoogryl benzylamine. These compounds are soluble in most of the common organic solvents.

BAÑGOS CULTURE IN THE PHILIPPINE ISLANDS

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SIXTEEN PLATES AND SIX TEXT FIGURES

INTRODUCTION

Of more than sixteen hundred kinds of fishes recorded from the Philippines, bañgos is the first in importance. It is by far the leading fish in Manila markets, and is the product of an industry in which over 45,000,000 pesos are invested around Manila Bay alone. Bañgos is the daily staple animal diet of tens of thousands of Manilans, and in the typhoon season is the only cheap fish available. Bañgos is shipped almost daily either by train or motor truck from Hagonoy, Bulacan, Navotas, and Malabon to various towns of Mountain, Pangasinan, Tarlac, Nueva Ecija, Bulacan, Pampanga, Laguna, Batangas, and Tayabas Provinces. In the interior towns of the above-named provinces bañgos in all forms finds a very good market and plays an important part in the diet of all classes.

Bañgos, like shad, is so excessively filled with minute bones that it is not eaten by people unaccustomed to it as long as the market is well supplied with fishes having fewer bones. The bañgos that is found in the markets ordinarily is just a few months old. The adult is seldom caught and is consequently rare; owing to its great size, fine bones are little evident and such a fish is exceedingly toothsome and commands a high price in all parts of the Islands.

In suitable natural localities, with fairly favorable marketing facilities the culture of bañgos is one of the most profitable industries in the Philippines. Throughout a large part of the Islands one monsoon may bring a glut of fish to the shores, with a corresponding scarcity during the opposite monsoon. In every such locality bañgos ponds are desirable and profitable, if the countryside is at all thickly settled, even though there is no large town close at hand.

During the rainy season there may be weeks in succession when no fish can be caught in the sea. At such times the bañgos grower reaps a harvest, if he has managed his fish properly; and he can usually obtain better prices than in Manila, because he has less competition.

Persons about to engage in bañgos culture are urged to spend sufficient time in the vicinity of Malabon to acquaint themselves with the most efficient methods of fishpond construction and of bañgos culture. Such things as the proper way of handling the flow of water, the care of the fry, and the growth of lablab and of lumut are better learned from example than from a book.

DESCRIPTION OF THE BAÑGOS

The bañgos, *Chanos chanos* (Forskål), is as beautiful as it is important commercially. It is a large, brilliant, shiny, silvery-white fish with a pale steel-bluish back. The compressed body, covered with small, smooth scales, has an almost regular spindle-shaped outline. There is a single fin at the back inserted just behind the highest point. The large tail is deeply forked. The head although small is in pleasing proportion. The mouth is terminal, oblique, and toothless. A thick gelatinous substance, very thick at the eye region, covers the snout up to the nape and the eye and its neighborhood.

FOOD OF THE BAÑGOS

The bañgos feeds upon diatoms and other plankton organisms, the leaves of submerged flowering plants, and algæ; it consumes large quantities of the filamentous green algæ. The fry feeds upon plankton and the surface scum on the muddy bottom of quiet shallow bays and tidal creeks. When food is plentiful the bañgos grows very rapidly.

DISTRIBUTION OF THE BAÑGOS

Although the bañgos was first described as coming from the Red Sea, it has a very wide distribution. It occurs throughout the Philippines, often entering the fresh-water rivers and lakes. It is found on all the coasts in the Indian Ocean as far south as Zanzibar, on the coasts of Asia and Formosa, and is seen occasionally along the coasts of southern Japan. In the Pacific, the bañgos may be found about Hawaii, Samoa, the East Indies, and the Society Islands and even as far south as

Australia and New Zealand. It is abundant in the Gulf of California and along the coast of Mexico.

In many parts of this immense range the bañgos is prized as food, in spite of the excessive number of fine bones. The flesh has a bland delicate flavor, and for this reason bañgos is sometimes called "milkfish." The bañgos is a fish of the open sea, and a swift and powerful swimmer. It rarely approaches land or enters shallow water except during March, April, and May. At that time some of them are caught in gill nets and fish corrals. The bañgos has such tremendous leaping power that it frequently escapes from nets and corrals. A bañgos two-thirds of a meter long can easily leap a distance of 10 or 12 meters, at the same time clearing obstructions 2 to 4 meters above the surface of the water. In a straight upward leap it can probably rise 5 or 6 meters from the water.

In the Philippines, as far as can be definitely ascertained, the bañgos spawns during April and May. It seems to spawn in quiet shallow sandy bays, where the fry are found along the shore in immense numbers.

EGGS OF THE BAÑGOS

The bañgos is among the most prolific of fishes. One of the ovaries of a ripe female taken in Subic Bay on April 10, 1927, measured 330 millimeters in length, 89 in extreme breadth (35 at the anterior, and 24 at the posterior, extremity), 40 in extreme thickness, and weighed 450 grams. The other ovary was equally large but had been damaged in removal. Bañgos eggs are very small. The ovaries of this specimen contained 3,415 eggs per gram. One ovary contained about 1,530,000 eggs; therefore, the fish had about 3,060,000 ripe eggs ready to spawn. This fish was about three-fourths of a meter in length. It is a safe assumption that fish half again as large would contain many more eggs.

In Batavia, Java, Dr. A. L. G. Seunier examined the roe of a fish 1,120 millimeters long, including the caudal fin (probably about 940 or 950 millimeters in real length). The roe weighed 1,304 grams, and one gram contained 4,370 eggs, making a total of about 5,700,000 eggs in the whole roe.

This shows that the number of eggs per gram varies considerably. Of course the larger the fish, the larger the roe. An increase in the length of a fish means a far greater increase

proportionately in its bulk. A bañgos a meter and a quarter in length, not counting the caudal fin, is, perhaps, at least twice as large as one three-fourths of a meter long. It seems probable that a bañgos never contains less than a million and a half eggs, and that a very large female may have in excess of 7,000,000 eggs. Bañgos average 3,000,000 eggs and can only be exceeded, if at all, by the cod, which has been known to have about 9,000,000 eggs.

I have not seen bañgos eggs after they have been spawned, but they seem to be demersible, and not of the floating type.

BAÑGOS FRY

The minute bañgos fry swim in vast shoals near the shore line of shallow sandy coasts and enter estuaries and tidal creeks. They come in with the advancing flood tide and go out with the ebb, and therefore are always surrounded by fresh, cool, but shallow water. A knowledge of this fact is fundamental to the successful culture of bañgos.

The capture of bañgos fry (kawag-kawag in Tagalog) is a very important industry. The flat sandy coasts of Balayan and Batangas Bays, Batangas Province, Luzon, furnish by far the largest quantity. The annual license fees for catching bañgos fry in Batangas Province during April, May, and June amount to about 100,000 pesos. The fry captured are shipped to Malabon and other points on Manila Bay, there being no bañgos ponds in Batangas Province.

Large quantities of bañgos fry are also caught and shipped to the Manila Bay bañgos growers from Mindoro, Marinduque, Tayabas, Sibuyan, Samar, Leyte, Tablas, Zambales, Pangasinan, La Union, and Ilocos Sur. Recently shipments are being made from Dumaguete, Oriental Negros. Most of the shipments are made in native sailing boats, but a good many are sent by truck to some railroad point or steamer. Bañgos fry are shipped from points as far as 800 kilometers from Manila.

The fry are caught in exceedingly fine-meshed nets, made of coarse sinamay (abacá cloth). Most of them are caught from the middle of April to the latter part of June, but they can sometimes be caught during the early part of July.

When captured, the fry are about 10 millimeters long and exceedingly slender. They are so small and transparent as to be nearly invisible. As soon as possible they are placed in low, wide-mouthed, pot-bellied, unglazed, earthenware jars (palayok

or palyok), some of which have a capacity of about 15 liters each, and others 30 liters. From about 1,500 to a little over 2,000 fry are placed in the 15-liter jar and 3,000 to 3,500 in the 30-liter jar. The jar is then covered with a piece of the base of a leaf stem, or petiole, from the areca, or betel-nut, palm. This is the most critical stage in the handling of bañgos. A little carelessness may ruin the whole stock in the jar. The jar should be kept filled with clean water so that the fry may move about freely, and should be handled carefully to avoid injuring the tender fry.

Vitality is the prime requisite for bañgos fry. They should be obtained from the nearest locality and placed in the nursery pond as soon as possible. Naturally those coming from faraway places are weakened by their long journey in confined quarters, often without change of water. The fry from Batangas are considered the best, but that is merely because they have been in captivity a short time. Around Manila Bay the best fry are those offered for sale the latter part of April and early part of May, since in June they are more likely to have been in the jars a good while.

At Manila the fry are usually purchased by men from Malabon who make a business of handling and rearing them and of supplying fishponds. Some of the owners of the large fishponds receive their supplies of fry direct from the Batangas fishermen.

When the fry arrive at the final destination the jars are carefully examined, all dead fry removed, and undesirable fishes rejected. Every effort should be made to see that the fry in each jar are of uniform size and vigor. Usually from 5 to 10 per cent in each jar die in transit, and in the jars that are shipped long distances the mortality reaches 25 per cent.

After the dealer has sorted the fry, the purchaser counts them. Manifestly, it would be impracticable to count the fry in all the jars, which sometimes number 500, so an average is usually taken by counting the contents of ten jars. In counting the fry a wide-mouthed china bowl is dipped into a jar and filled with water and fry. Then a clam shell is dipped into the china bowl and several fry are taken up in it. The counter calls out the number of fry in the clam shell and the number is checked by two tellers. This operation is repeated until all the fry in the jar have been counted. When all the fry in the selected jars have been counted the total number is divided by

10 and the result thus obtained is taken as the average number of fry in each jar. The average multiplied by the total number of jars gives the total number of fry in all the jars.

Fry are bought and sold by the ten thousand, or lacsa. The price varies at present (1927) from 15 to 50 pesos per ten thousand, according to the season and place. In general the price is lower in the vicinity of Malabon, and higher in Bulacan, Pampanga, and Bataan; it is also higher early in the season as the best fry are then available. The danger of heavy rainfall during the latter part of May and in June also reduces the price, since heavy rains cool the ponds and reduce the salinity of the water, weakening or even killing the fry.

Other fishes are often mixed with the fry in the jars; some are harmless, but many of them are injurious. The commonest fry found with schools of bañgos are bid-bid (*Elops hawaiiensis*), buan-buan (*Megalops cyprinoides*), several kinds of banak (*Mugil* and *Liza* sp.), and several kinds of gobies. Very young shrimps may also be found in the jar.

It is difficult to tell very young bid-bid and buan-buan from bañgos fry, for they are related and look much alike. Usually bid-bid and buan-buan are more active and a trifle larger. They should be removed at this stage, for they grow faster than the bañgos fry and soon begin to eat them. Young gobies are not as hard to detect, but are equally undesirable since they devour large quantities of bañgos fry.

Banak, or mullet, are not at all harmful, because they too are vegetable feeders; they are a valuable food of superior flavor. It is claimed that shrimps are not harmful and that they do not eat bañgos fry. This is very doubtful since certain kinds of shrimps of any size would certainly kill and eat all the fry they could catch. I believe that shrimps should be eliminated from the nursery pond as far as possible and also from ponds containing bañgos in the next stage of growth. After the fish has reached a length of from 40 to 50 millimeters, the presence of shrimps is not objectionable and indeed may be desirable, as they are readily salable at a good price. They act as scavengers, without interfering in any way with the bañgos or reducing the food supply.

THE BAÑGOS IN FRESH WATER

The bañgos often enters fresh-water rivers, and if there are large fresh-water lakes near sea-level it travels up stream to them. Lake Taal, Lake Naujan, and Lake Bato are the tem-

porary homes of many bañgos, but the water pollution and the large amount of river navigation attendant upon the growth of Manila, seem to prevent the bañgos from entering Laguna de Bay any more.

The bañgos remains in these lakes for several years, until it is two-thirds of a meter or more in length. Although these lakes are large, Lake Taal being somewhat more than 27 kilometers long and 20 kilometers wide, with a depth of nearly 200 meters in places, the bañgos never reaches sexual maturity here. Finally, when it feels the urge to return to the sea it starts down the outlet of the lake. At this stage it is called "lumulukso," a Tagalog word meaning "leaping," or "jumping," because of its astonishing jumps when in danger.

Very few of the bañgos in Lake Taal or Lake Naujan reach the sea, since the narrow outlet to each lake is completely closed by an immense, tightly woven, fish corral. Occasionally a fish leaps over the walls and gets away, but the number doing so is negligible.

THE BAÑGOS DOES NOT BREED IN CAPTIVITY

The bañgos only reaches sexual maturity in the open sea. Seunier, in his book on the marine fishponds of Batavia, states that in October, 1920, he was shown bañgos roe which was said to have been taken from a fish five years old, kept in a pond near Bangil, Java. Experiments by fishpond owners near Batavia, Java, and around Manila Bay have failed to produce sexually mature bañgos, even when the fish have been kept for as many as six years.

Fishponds are too small and the fish too crowded for the bañgos to reach its maturity rapidly. Other factors, such as the different chemical composition of the sea water and the different food obtained in the open sea, may also be necessary for its sexual development. The fact that it never reaches maturity in large lakes, such as Naujan and Taal, is very strong presumptive evidence that it will not do so in shallow artificial ponds, and that there are unknown factors essential to the development of the gonads.

SUPERSTITIONS ABOUT BAÑGOS FRY

According to the belief of old men in Batangas Province, bañgos fry originate in the following way: When the water is dried up and the soil exposed in swampy places in the interior, during the dry season, the ground is heated by the sun and

stirred into life. Light rain falling on it then causes the fry to form, and they are washed down by the river into the sea. As proof of their story the narrators point to the abundance of bañgos fry in the mouths of creeks and rivers.

In many parts of the Visayas and Luzon it is believed that bañgos, and also buan-buan and bid-bid, are generated spontaneously in fishponds. This is because the minute fry, entering with the flood tide, are overlooked.

ORIGIN OF THE FISHPOND INDUSTRY

The combination of desirable characters in the bañgos early attracted attention in many lands. Rapidity of growth, vegetarianism, absolute lack of cannibalism, the ease with which the fry could be secured in large numbers, the savory quality of the flesh, and other attractive qualities were factors not combined in any other fish of the same habitat.

It is impossible to say when men first constructed fishponds in the Indo-Pacific region, but the bañgos culture of to-day is the result of a gradual development over a period of many centuries.

The first fishponds for marine fishes were made by walling up the narrow entrance to a bay or inlet. An opening was left so that the fishes borne by the incoming tide could freely enter, after which it was closed by a gate which prevented their exit but allowed the interchange of water. Manifestly there was little control over the stocking of ponds by this method, and the results obtained were altogether a matter of chance.

BAÑGOS PONDS IN HAWAII, FORMOSA, AND JAVA

The greatest development of ponds of this character was in the Hawaiian Islands. The origin of these ponds is lost in antiquity, but some of them built two or three hundred years ago are still in use. However, the changes in population and crops have caused most of the ponds in use fifty or a hundred years ago to be turned to other uses or abandoned. Some of the Hawaiian ponds were very large, 200 hectares or more in a single inclosure. Most of them were made by building walls of lava across the narrow entrance to a bay and placing a sluice gate at a convenient opening. The principal fishes in the Hawaiian ponds were and still are mullet and bañgos.

The same principle was utilized in the construction of fishponds in Java, Madura, the Philippines, Formosa, and perhaps in other localities. As time went on various changes

were introduced. In the East Indies the extensive nipa swamps along the coasts were at first exploited solely for thatch and for the alcoholic beverage made from nipa sap. Later those in proximity to well-populated regions offered large areas ready to be converted into fishponds, merely by constructing a dam or dike to impound the water at high tide. Eventually, after the lapse of centuries, people in the more-advanced regions ceased to stock their ponds by chance. Instead, they adopted a set method of collecting the desired fry and put them into especially constructed ponds in place of those more or less naturally suited for the purpose.

Accordingly there came into existence around such favorable localities as Batavia and Surabaya, Java, Madura, Singapore, and Manila an enormous fishpond industry whose extent and importance are realized by few individuals not connected with the industry. Just when and where the construction of ponds from nipa swamps originated cannot be determined, but it was more than five hundred years ago.

The Dutch author C. Th. van Deventer, writing on the economic condition of the inland population of Java and Madura, records that the ancient Javanese laws punished "him who steals fish from a tambak," or artificial salt-water fishpond. These laws were codified about 1400 A. D., and of course fishponds must have existed before that time. The bañgos industry is evidently very ancient in Java.

BAÑGOS CULTURE IN THE PHILIPPINES

It is impossible to state when the construction of fishponds or the culture of bañgos began in the Philippines. It probably started on the shores of Manila Bay, around the city of Manila. There have also been bañgos ponds around Iloilo and on Mactan Island for a long time. For untold decades all fishponds in the Philippines were of a primitive type; the chance entrance of bañgos and other fishes was depended upon to stock them.

On Mactan Island opposite the city of Cebu this ancient style of pond continued till 1921. Mactan Island is a coral reef very little above high tide, and intersected by several salt-water tidal creeks. In places low dikes were constructed and at high tide the hollows among the rocks were filled with water, after which the gate was closed. Sometimes a good many bañgos entered, but their enemies also entered and not many bañgos survived. At the end of the season the pond was

drained, and if the owner obtained 25 to 40 pesos for his bañgos he thought he had done remarkably well.

About 1920, Dr. Pio Valencia, a Tagalog practicing medicine in Cebu, acquired an ancient fishpond on Mactan Island. He purchased a quantity of fry, stocked the pond, and at the close of the season sold the fish for 500 pesos, to the great astonishment of the local people. This result was obtained without any improvement of the pond and shows the difference between chance stocking and intelligent planting of bañgos fry. Later Doctor Valencia acquired more fishpond land and made extensive alterations and improvements until he has a fine modern plant.

Many of the fishponds in Iloilo Province and elsewhere in the Visayas are of the same ancient type, still being stocked by chance, the proprietors merely opening the gates at flood tide and allowing what will to enter. As a result, the Visayan fishponds contain a much more heterogenous assembly of fishes than the ponds around Manila Bay.

The Philippine bañgos fishpond industry has reached its highest development around Manila Bay, and the most skillful practice is in the region about Malabon, a town a short distance north of Manila. The largest ponds are found in Pampanga, Bulacan, and Bataan. The industry has likewise been developed in Iloilo and Capiz Provinces, and has been established in a minor way in La Union, Pangasinan, Zambales, Cebu, Oriental Negros, and other provinces.

VALUE OF PHILIPPINE BAÑGOS PONDS

The bañgos fishpond industry is really a major industry, and is a source of large revenue to the government of several provinces, even to some that have not a fishpond within the boundaries. Bulacan Province, with 3,193 hectares of land devoted to the fishpond industry, receives 118,000 pesos annually from taxes on its fishponds; while Batangas Province, with no fishpond within its boundaries, collects about 100,000 pesos from municipal licenses for catching bañgos fry. These fry are sold to growers about Manila.

It is impossible to state the exact amount of land devoted to fishponds about Manila Bay, but the approximate areas in the various provinces are as follows: Rizal Province, 3,193 hectares; Bulacan, 16,700; Pampanga, 14,200; Bataan, 4,000; Cavite, 659.

The market value of bañgos ponds about Manila Bay varies from 500 to 2,500 pesos per hectare. The value of a pond depends upon the distance to market; the distance to the open bay; the volume of water and its depth in the adjacent river or creek; the age of the pond; the quality of the soil in relation to the growth of lumut; the cleanliness of the pond, that is, its freedom from mud, grass, brush, etc.; and the liability to flooding by fresh water.

In general, bañgos ponds are more valuable in Malabon, Navotas, Obando, Bulacan, and Hagonoy and decrease in value as the distance from Manila increases. A conservative estimate of the value of the bañgos fishponds in the provinces listed above is over 45,000,000 pesos.

In Iloilo and Capiz Provinces there has been a rapid increase in the number of fishponds during the past few years and there are now about 900 hectares in operation, with an approximate value of 600,000 pesos. If the value of fishponds in Zambales, Pangasinan, La Union, Cebu, Oriental Negros, and other provinces is added, it is found that more than 46,000,000 pesos are invested in fishponds in the Philippine Islands.

The returns from bañgos ponds vary greatly and depend upon the management, the distance to market, the cost of transportation, and the weather conditions.

INCOME FROM BAÑGOS PONDS

The best fishponds, carefully managed, yield an annual income of 300 pesos per hectare. There are only a few owners, however, who get such good results. Some ponds bring in about 250 pesos per hectare; only ponds kept in very good condition do this well. Third-class ponds make a profit of 200 pesos a hectare each year. Ponds kept in good condition should do better than this, unless they are far from a good market and have poor transportation.

CONDITIONS AFFECTING THE SALINITY OF PONDS

The water in a bañgos pond varies greatly in its salinity, which is affected by the following:

Its nearness to open salt water, so that the stale water released may be replaced by, (*a*), sea water let in at high tide; (*b*), brackish or even fresh water entering from creeks, rivers, or canals.

Circulation within the system as the water is allowed to go from one pond to another.

Evaporation.

Rainfall.

Freshets or floods, as when fresh-water rivers overflow and burst the dikes separating them from the ponds.

The entrance of ground water or subterranean springs flowing in from below.

The entrance of artesian water; there are many artesian wells in the fishpond belt along the northern shore of Manila Bay.

During the dry season (March, April, and May) the salinity may rise to a high figure, but it drops greatly with the first heavy rains in June.

SELECTION OF A FISHPOND SITE

Salt-water fishponds in which bañgos are reared are called "plaisdaan" in Tagalog, "pocóc" in Pangasinan, "pocóc," "potót," and "lapát" in Ilocano, and "ponong" in Visayan. They vary in size from one-eighth of a hectare to 68 hectares as on the estate of Carlos Palanca, near Hagonoy, Bulacan. A system of fishponds under one management may contain hundreds of hectares, as the Ayala and the Carlos Palanca estates in Bulacan and Pampanga.

Large areas of swampland or tidal flats suitable for fishponds occur along the sea coast in many localities in the Philippines. In general, four factors are of prime importance in choosing a site; namely, the soil, the vegetation, the proximity of a deep tidal stream, and the market.

The soil.—Clay is the most desirable soil. It is not only retentive of water but is also best for the growth of the vegetation upon which bañgos feed. Sandy soil is, of course, not practicable, and soft mud is unfavorable to a good growth of algæ and injurious to the fish.

The vegetation.—The ideal land for a fishpond site is peat or tule land, as there is practically no clearing to do. As soon as the dikes and the sluice gates are built everything is ready for use. The commonest type of salt-water swamp in the Philippines and next best for fishpond purposes is nipa-swamp land. The nipa palm is easily cut off. It is not necessary to remove all the plants and stumps before using the land for a fishpond; in fact, it is often advisable to leave a few trees for shade. When the leaves are kept cut off and the terminal bud is destroyed the nipa plant soon dies. The stump rots quickly and is then easily removed.

Mangrove swamps are less desirable because the trees are larger, have hard wood, are more difficult to cut, are not easily

killed, and the removal of the stumps is much more laborious. Some mangrove trees may be left standing in a fishpond, but only a very few. Their spreading roots and sprouted fruits which are all ready to take root as soon as dropped are likely to be harmful to the pond.

The proximity of a deep tidal stream.—Great care should be taken that the fishpond is sufficiently near a deep tidal stream to insure a plentiful supply of salt or brackish water throughout the year, especially during the dry season. The ideal situation is in the angle between a tidal river and a tributary tidal creek. The water can then be taken in during high tide at the highest point on two sides of the plot and released at low tide at the point farthest down on the main stream. Land with fresh-water streams crossing it and land that is subject to flooding by fresh water during the rainy season should be avoided. If the site selected is by a very shallow tidal stream it often happens that during the dry season the bed of the stream becomes partially or even wholly dry. At such times the water in the pond may not be changed for some days, with harmful results to the bañgos.

The market.—It would be useless to have a bañgos pond without a market close by or else adequate cheap transportation to a good market. Some producers on Manila Bay use launches to take their fish to Manila. Others sell to middlemen or ship to Manila by truck or by small steamers. The bañgos grown at places some kilometers in the interior are shipped by truck to interior towns in Bulacan, Pampanga, and Tarlac, where there are no sea fish. On large coco and sugar plantations convenient to the sea bañgos ponds would be an excellent investment. Where salt water is not available, fresh-water ponds for the breeding and cultivation of carp and gurami should be a part of the central plant.

CONSTRUCTION AND ARRANGEMENT OF BAÑGOS PONDS

The cost of constructing a fishpond varies with—

- The soil to be worked; as, clay, mud, or rock.
- The topography, whether level, sloping, or undulating.
- The vegetation present; nipa, mangrove, small bushes, cat-tails, sedges, lotus, or other herbaceous swamp plants.
- The labor conditions in the locality.

After the site has been selected, the next step is to construct the main dike about the pond. After the location of the dike

has been marked off, the soil should be removed along the course to a depth of 30 to 60 centimeters, according to its character. Every stump, log, and stick of wood should be removed, for if left, they will rot sooner or later and ultimately let water escape.

The base of the dike should be not less than 4 to 5 meters wide, and it should rise well above the level of the highest tide or the height reached at any time by floods during the rainy season. The top of the dike should be a meter in width. Some well-made ponds have dikes of larger dimensions, wide enough at the top for a wagon or an automobile to pass along them, but such construction is ordinarily not necessary.

In the Manila Bay region where the soil is easily worked the laborers sometimes contract to build a section of dike 20 meters long, 3 meters wide at the base, and 1 meter 30 centimeters wide at the top for 20 pesos. When the soil is hard to work, such a section costs from 25 to 40 pesos. A much commoner method is to hire a gang of laborers and pay them by the square braza, the earth being excavated to a depth of 36 centimeters. The Spanish measure braza equals the English nautical fathom, or six feet. For each square braza, where the soil is easily worked and conditions are normal, the laborer receives 30 centavos. Where the ground is high, hummocky, or with large termite hills, the depth of the soil removed must be doubled or trippled as the case may be, with a corresponding increase in the cost of dike construction.

The soil for dikes is taken from the inside of the pond next to the embankment, thus forming a marginal trough, or ditch, deeper than the rest of the pond.

In building a dike the laborers work in two gangs. One group does the excavating, using a kind of handleless shovel, removes the soil in blocks, and places the blocks in a banca. The banca is then taken to where the work of dike building is proceeding. Here the second group of men passes the blocks of muddy soil from hand to hand till the last man sets them in place, as shown on Plate 3, figs. 2 and 3, and Plate 4, fig. 3. The tramping of the laborers in usually sufficient to solidify the dike, but if the soil is at all loose it should be well pounded to make the dike firm.

Where mangroves are abundant the construction of a pond is more expensive. The trees must be cut and their extensive root systems destroyed, all of which adds to the expense. On the other hand mangrove wood is esteemed as fuel, and the hard wood makes excellent charcoal. Greater care must be

taken in making the dikes in a mangrove swamp, and the stumps, roots, old logs, and limbs should all be removed.

Often the soil in a mangrove swamp is so full of half-decayed roots and twigs that the dike is easily set on fire during the dry season. Such a dike is also weaker than one of clay alone. The danger of fire is also a drawback to the selection of peat land for a fishpond.

A dike must be watched constantly to prevent breaks, to stop leaks or holes, to strengthen weak places, and to overcome the effects of settling. Burrowing animals of various kinds make holes in the dikes, through which water escapes with rapidity. During the rainy season rivers may become swollen and have swift currents which often undermine or cut through the dikes. Tides of unusual height must also be guarded against. In the Philippines, the highest tides are in January. A dike should be gone over thoroughly every year and repaired or strengthened. In mangrove or peat lands the dike will become more compact and therefore lower; and if a little more soil is added each year, in the course of a few years the dike will become solid and stronger than ever.

Where a fishpond is located beside a deep river or stream, or is exposed to the attacks of currents of either fresh or salt water in times of freshets or unusual high water, the dike can be further strengthened by various means. The ordinary way is to build the dike over a central wall of bamboo stakes; more rarely wooden piling is used. Sometimes a row or two of bamboo or hard-wood piling is placed along the exposed side of the dike, or it may be faced with planking.

Sometimes the dike is made stronger by planting mangrove trees along its top or along the exposed side. The spreading habit of the mangroves, and the dropping of their fruit seedlings in the fishpond are objectionable, but these can be watched carefully. In some places nipa is planted or left growing along the base of a dike next the river supplying water to the pond. It prevents floods from injuring the dike, and the sale of nipa leaves as thatch provides a small additional income. In Java, coco palms are planted on the dikes by some fishponds owners; these strengthen the embankments, give shade, and provide revenue. Mangroves are also frequently planted on the dikes of Javanese ponds. There are a few fishponds in the Philippines where cocos have been planted along the dikes.

A bañgos pond should never be deeper than the river beside it; its deepest part should always be slightly higher than

the stream at its outlet during ordinary low tide. The main part of the pond may be very shallow, the water over most of it with a depth of perhaps half a meter. Around the margins where the earth was removed to form the dikes it is, of course, deeper. In large ponds two more ditches are dug, each one connecting the centers of opposite sides of the rectangle and intersecting each other at right angles. All these ditches should be made with the bottom sloped so that all the water will drain readily to the outlet of the pond. Ponds of great extent may include part of a creek or even several small creeks, in which the water may be two to several times deeper than elsewhere. Such channels are beneficial in providing cool areas for the fish to lie in when not feeding and are convenient when it is necessary to do repair work or clean a pond, as the fish can retire to them when the rest of the pond is partially or wholly bare.

A bañgos pond is of necessity divided into several compartments or made up of several connecting ponds which are operated as a unit. A fishpond should be divided into not less than four smaller ponds, or compartments, and as many more may be made in large ponds as are found necessary. These ponds naturally vary in size and depth, since they must accommodate fish of different sizes and are used for different purposes. One of the ponds in the system should be very much larger than any of the others. Where the total area is small and there are but four or five divisions in all, the largest division should be as large as all the rest taken together. In a fishpond system of any size it is necessary to have a small catching pond, into which the fish are led when they are to be caught for market.

As bañgos ponds are constructed on tide flats, where the land is uniform in topography, they are usually rectangular in shape. There may be exceptions to this caused by the meandering of bordering creeks from which the supply of water comes.

The partition dikes, or those between the small ponds, are low, usually narrow, and are never as strongly built as those around the outside of the system. The small ones may be 25 centimeters wide at the pond level and hardly wide enough at the top to provide safe footing; the large ones may be a meter or more at the water level and a meter wide at the top. When they are temporary the width makes little difference, but if they are to be permanent they should be strong enough to with-

stand ordinary wear and tear and to permit free passage along their tops.

Gateways are, of course, necessary in the dike, to control the intake and outlet of water. Most fishponds are built with but one main sluice gate, but the best method is to have a gateway

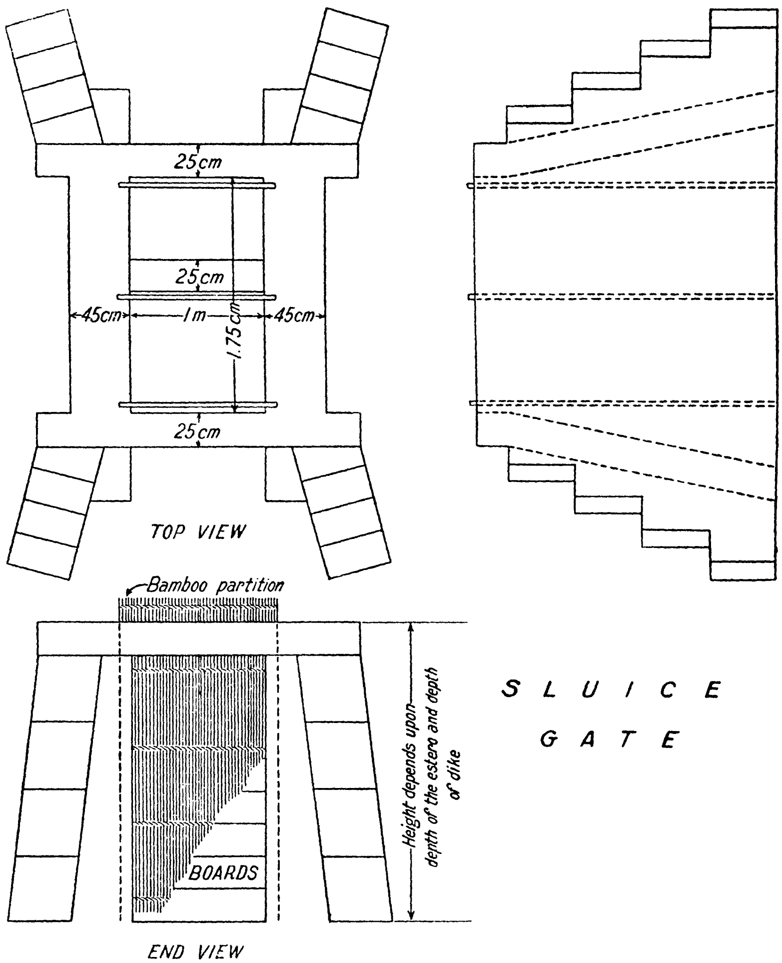

FIG. 1. Plan and elevation of fishpond sluice gate.

at the highest point or place farthest away from the sea, where water may be taken in at high tide, and another sluice gate at the lowest point, so that the pond may be easily drained at low tide.

The main gate or gates should be constructed of concrete. Formerly they were made of stone, and cement, brick, or even

of wood, but the superior merit of concrete construction is gradually forcing out all other methods. In some regions the main gates are still simple in construction and made of wood, as a rule. The main sluice gate should be of ample dimensions, with a large base. If the base is too small the gate will settle unevenly in time, cracks may form, and the gate become practically useless. If the ground is very soft or lacks uniformity it is often necessary to drive it full of bamboo or hardwood piling and place over this a kind of bamboo raft which supports the concrete foundation. The opening for the passage of water in a sluice gate is about 1 meter. The cost of such a concrete sluice gate varies from 700 to 900 pesos. Its general appearance is well shown on Plate 4, fig. 2, and Plate 13, fig. 2.

The main sluice gate should be so made that three sliding doors or gates, moving up and down, may be used. When they are all in place they inclose two spaces within the gate. The principal door is in the middle and is composed of closely-fitting slabs or boards of very durable wood placed edge to edge. These may be added or removed to regulate the flow of water or to stop it altogether. At the entrance and the exit of the sluice gate are sliding doors made of closely woven split bamboo. These doors allow water to pass through freely but prevent more or less successfully the entrance of undesirable fishes, crabs, water snakes, and other aquatic enemies, and prevent the escape of bañgos. However, shrimps are also considered so important a crop that pond caretakers encourage their entrance into the ponds.

In addition to the main sluice gate or gates, it is necessary in a good fishpond system to have small sluice gates of simple construction placed here and there to allow water and fish to pass from one pond to another. These secondary gates are usually of wooden construction and rarely have more than one door. They are small compared with the main gate and are usually not more than two-thirds of a meter in breadth, and very little if any longer than the width of the partition in which they are placed. They vary from temporary ones costing but a few pesos, to permanent ones that may cost 500 pesos or more. Sometimes some of the ponds are connected by hollow logs set in the dikes. This is a cheap way, but control is difficult. Some people even make ponds entirely separate

from each other. This may do for some fresh-water fishes, but is poor practice in bañgos ponds. In a first-class bañgos system all the ponds are connected so that water can be let into or drawn from any pond desired.

After the dikes, cross dikes, sluice gates, and other gates have been constructed and the pond system is completed, there are expenses not yet mentioned. There must be a caretaker close at hand at all times.

The caretaker must have a house of some sort. It is usually placed near the main sluice gate. The house may be a bamboo and nipa shed costing a few pesos or a well-built, modern cottage costing several hundred pesos. In many places an artesian well is necessary to provide drinking water. The cost of drilling a well is from 150 to 200 pesos. The usual wage received by the caretaker is 40 pesos a month, and often a liter of kerosene a week in addition. Some owners pay as little as 150 pesos a year; needless to say they do not get first-class service. Large systems of fishponds, ranging from 200 to 800 hectares in extent, pay good salaries to the resident manager, up to 350 pesos a month including a good house, light, and a motor boat for inspection trips. A fair average salary for the foreman in charge of a fishpond system of moderate size, 15 to 60 hectares, is 45 pesos a month.

Laborers must be employed to inspect and repair the dikes; to destroy snakes, crabs, and other vermin; to kill or scare away fish-eating birds; and to assist in transfering young fish and catching those marketable, changing water in the ponds, repairing nets, and the rest of the daily routine. Wages are from 1 to 1.50 pesos a day, depending upon the locality; near Manila they are higher, and in outlying provinces they may be much lower.

Several small bancas and one or more large ones will be needed for transportation along the river and in the canals and ponds. The number will vary with the size of the establishment and the number of workmen. Large drag nets, or seines, will be needed for catching marketable fish. Small fine-meshed nets (panagap) are needed to catch hatirin; these nets are from 6 to 8 meters long and 3 or 4 meters wide. Large long-handled dip nets are used for many purposes, and several of the square dip nets (bitinan) will be needed when hatirin are caught.

Small fine-meshed baklad are necessary for catching shrimps, or ulang and sugpo, and various kinds of crabs such as alimañgo and alimasag. All told these will cost from 100 to 200 pesos.

A large fish-pond system will need a motor boat to carry the fish to market, bring supplies, and make inspections. With a motor boat the owner can market his fish without delay and in first-class condition.

FISHPONDS IN THE VISAYAS

In general, fishpond construction in the Visayas is antiquated and much behind the standards set by the fishpond owners of Malabon, Bulacan, and Pampanga. There are some notable exceptions to this, particularly around Molo, Dumangas, Barotac Nuevo, and Banate, in Iloilo Province, and on Mactan Island.

A great deal of interest has been shown recently in the construction of fishponds in the extensive swamps and marshlands of Panay. Unfortunately few of the persons interested are informed about the proper methods of constructing ponds, raising bañgos, or of choosing a suitable location.

Not every swamp is suitable for the successful operation of fishponds. Owing to their general topography, many swamps are distinctly unfavorable to the development of fishponds. In the Visayas tidal swamps are often subject to one or both of the following disadvantages: (*a*) Exposure to the open sea so that the dikes are subject to erosion from strong waves, which damage them seriously and sometimes destroy them; (*b*) hills are so close to the ponds that the flood and rush of water from heavy rains washes out or damages the dikes, and the ponds are flooded so that their salinity is reduced too much. Both these disadvantages must be avoided.

The salt-marshlands of the Visayas are in general of three types; namely, rocky, nipa, and mangrove. The nipa swamps are by far the best adapted for conversion into fishponds, especially when located in the delta of a river. The soil in a nipa swamp is always retentive of moisture and favorable to the construction of fishponds.

The mangrove swamps are densely covered with hardwood trees, which are expensive to cut off, the stumps and extensive root systems of which are difficult and expensive to remove. Of course the sale of firewood and charcoal provides some return, but this will not equal the cost of removing the stumps.

In some instances the mangrove swamps have a soil of coral sand, which is very deficient in clay. In such places fishpond dikes are very easily washed away by waves or by freshets, and may be seriously injured even by high wind. Such swamps should be avoided for fishpond sites.

In some places, as on Mactan Island and the coast of Ilocos Norte, the swamps are very rocky, being really nothing but a slightly elevated ancient coral reef. Where the general level of a rocky swamp is but little above high tide, with many portions covered by salt water at ordinary low tide, the difficulties of making a good pond are not too great, provided there is a sufficiency of good clayey or impermeable soil. Unless there is enough soil to make good substantial dikes the loss of water by leakage becomes too great for successful operation. Where large rocks and outcropping coral ledges are numerous, blasting is often necessary to connect the intervening pools and get sufficient pond area of the proper depth.

In both mangrove and rocky swamps it requires much well-supervised labor and ample funds to construct a fishpond of fairly uniform depth, avoiding extreme depth or shallowness, with satisfactory dikes and gates.

Most fishponds in the Visayas are defective in the following particulars: (*a*) The nursery ponds are not well arranged and properly maintained, and in many cases are altogether lacking; (*b*) when they are present, small ponds are often not provided for the young fish when they are released from the nursery; (*c*) too little care is taken to free the fry from enemies such as bid-bid and buan-buan, and not enough pains are taken in preventing enemies from entering the ponds with the tides when water is changed; (*d*) a proper growth of lab-lab is usually lacking, so that a high percentage of kawag-kawag starves to death. In many cases ponds in mangrove swamps are made by merely damming a creek. Part of the inclosure is usually too deep for the successful growth of lumut, and other portions are too shallow. In some places ponds are located one behind another, each damming a portion of a small tidal river. This is poor practice, since only the outer one has free access to water, the inner ones being able to change water only as it is released by the one in front of them.

THE NURSERY POND

The most important division of a fishpond, and usually the smallest, is the nursery pond, in which the fry are placed.

This may be of any size, from a compartment 10 by 15 meters to a pond more than a hectare in area, according to the number of fry necessary to supply the ponds later. In most nurseries a small compartment (pabiayan) is made at one corner of the large inclosure. It may vary in size from 5 by 5 meters to 40 by 40 meters, according to the number of fry, and has an opening about 1 meter wide which leads into the nursery proper. Tubes are also placed in the dividing wall so that water may pass back and forth freely. A galao is placed over the inner end of each tube, and the other end is closed with a very fine screen, which effectively prevents all bañgos fry from escaping.

A galao is an elongate, fine-meshed, woven-bamboo basket, shaped like certain types of bobo, or fish traps. It is 1 meter long, 28 centimeters wide at the base, bulging out at the middle to 35 centimeters, and 18 centimeters wide at the upper end.

In large fishpond systems the nursery has a number of small inclosures, or pabiayan. Every other pabiayan is used for slightly older fry and is called a "bansutan." When a given batch of fry has been distributed in the pabiayan the fry are kept there a short time, about two or three weeks, or until another lot of fry is received. By that time they should have grown from 10 millimeters to 30 or 35 millimeters in length. Then the first batch is moved over from the pabiayan to the bansutan, and the new consignment is divided among the pabiayan just vacated. In this way the fry of a given size are kept to themselves.

The preparation of the nursery is a tedious, delicate, but very important task since upon its condition depends the success or failure of the fishpond as a whole. Not only are bañgos fry very delicate, susceptible to variations of heat and cold, but their food is entirely different from that of the older fish. Whereas bañgos kept in ponds feed largely or entirely on filamentous green algæ and the leaves of submerged flowering plants, the fry feed upon lab-lab.

LAB-LAB

Lab-lab is the Tagalog name for the plant complex that under certain conditions forms a crust or mat upon the floor of the nursery pond.

A microscopic examination of lab-lab shows it to be largely composed of unicellular, colonial, and filamentous blue-green

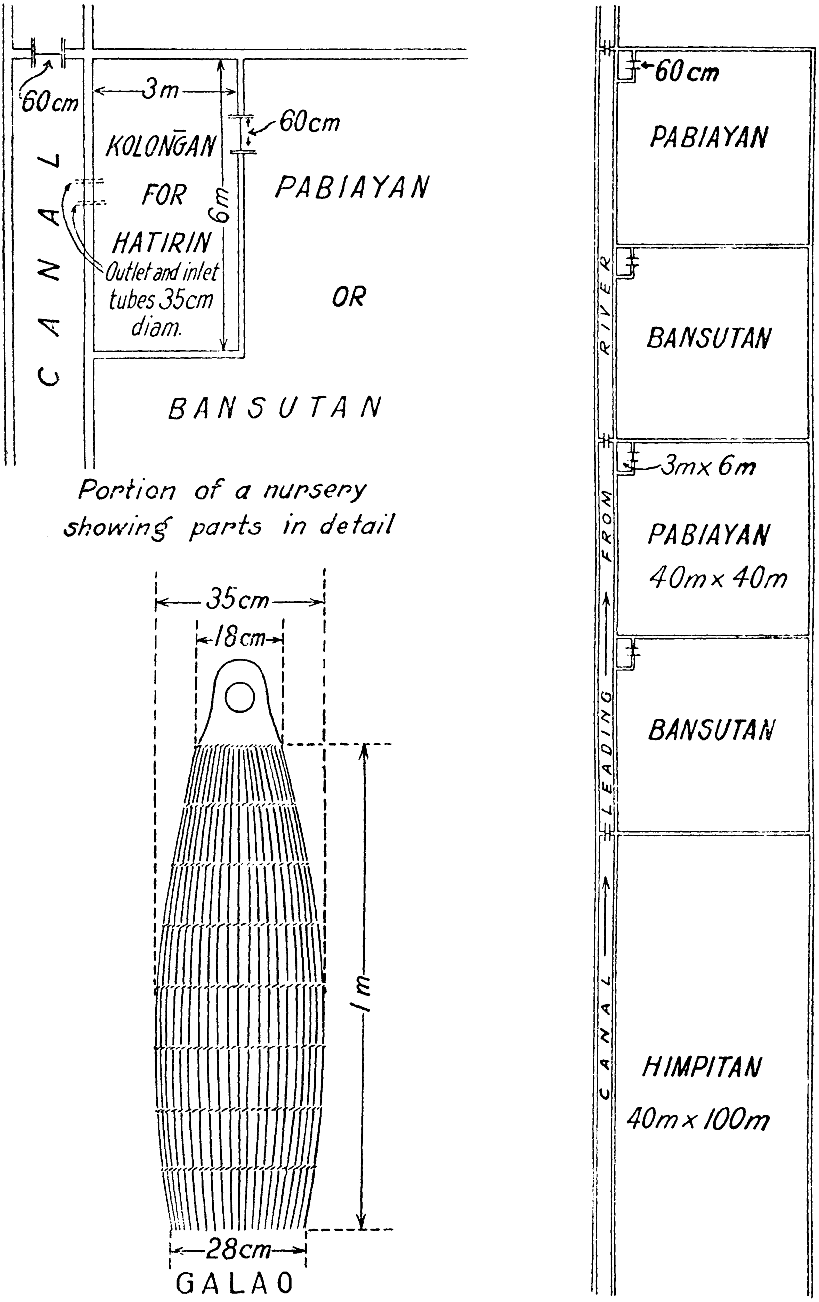

FIG. 2. Plan of a bañgos nursery pond, at Dampalit Barrio, Malabon, Rizal Province, Luzon. This pond is used for salt making during the dry season. Below, a fish trap (galao).

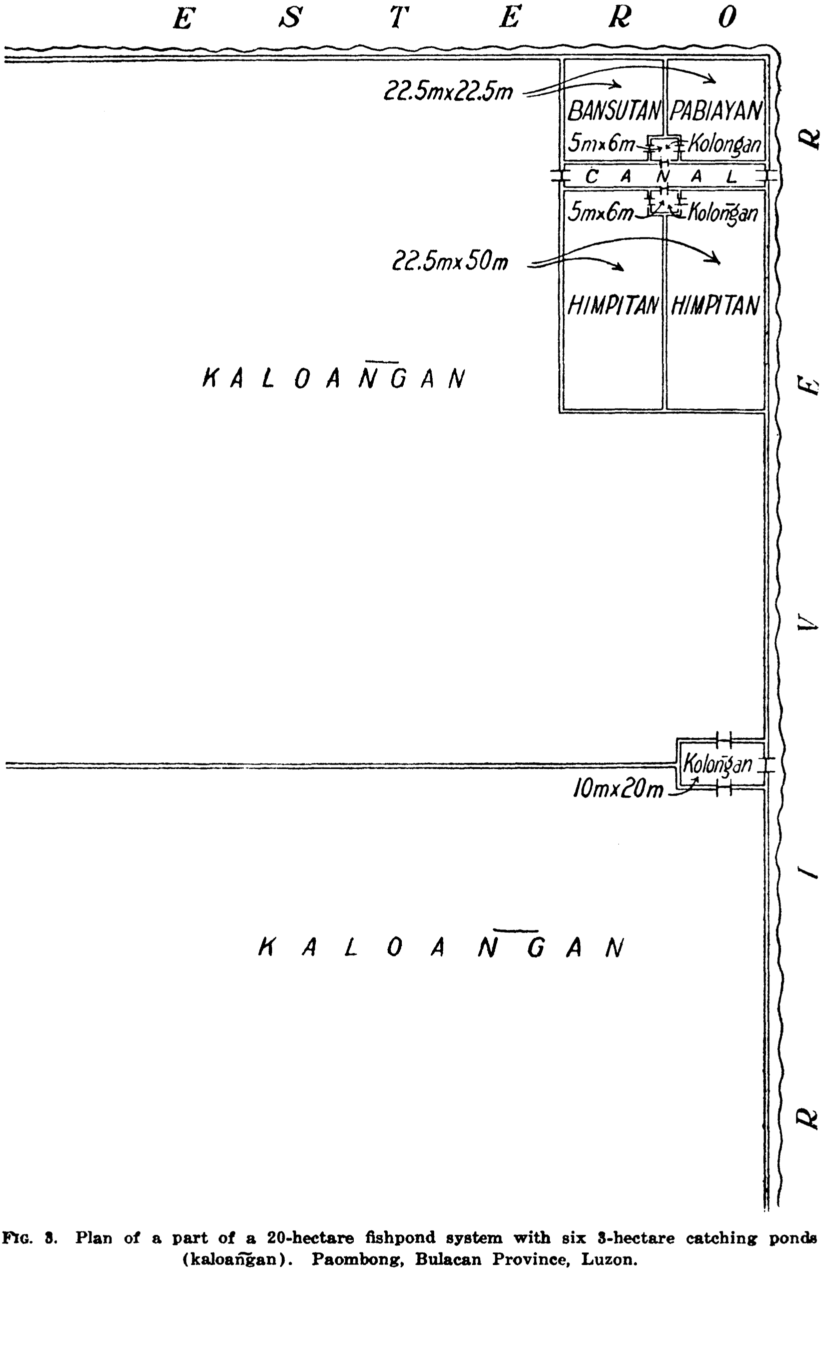

FIG. 8. Plan of a part of a 20-hectare fishpond system with six 3-hectare catching ponds (kaloañgan). Paombong, Bulacan Province, Luzon.

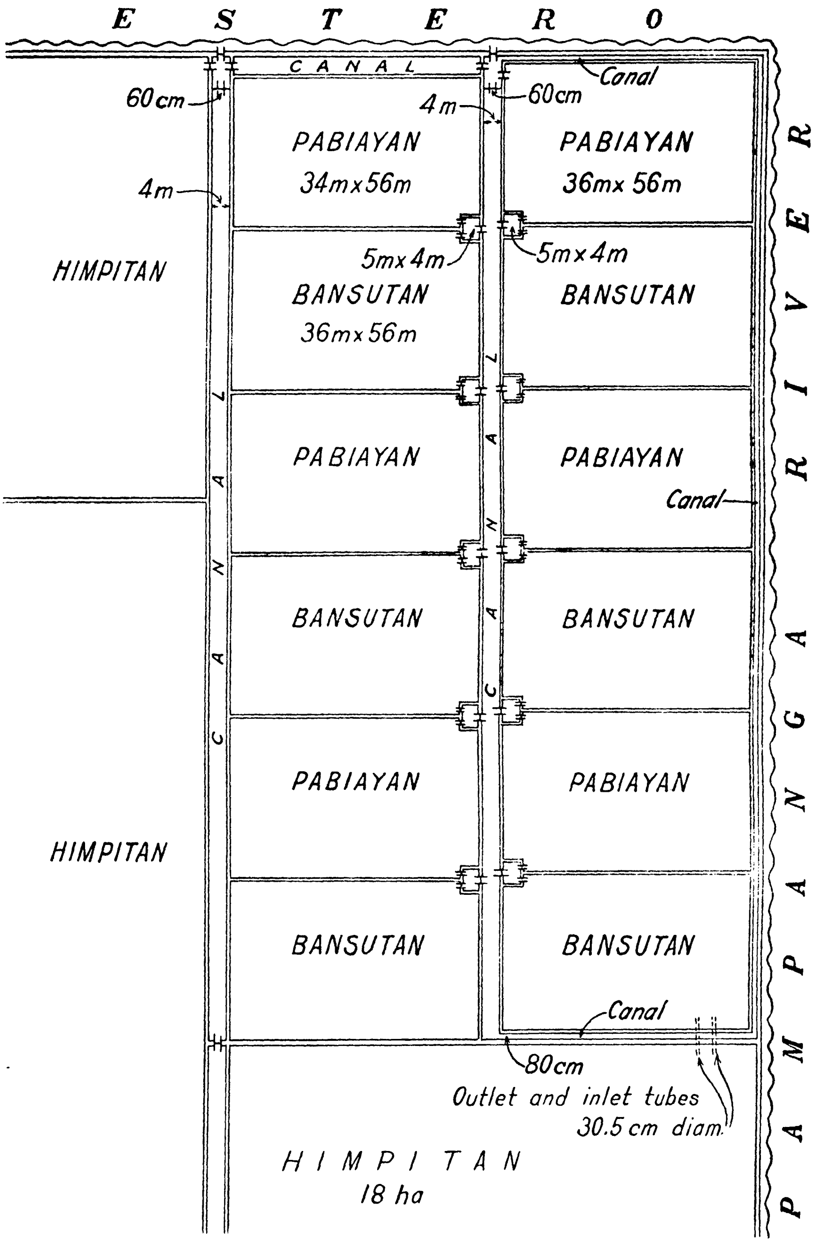

FIG. 4. Plan of a part of a 600-hectare fishpond system. The nursery will cost 4,000 pesos and will hold 1,500,000 bañgos fry (kawag-kawag). Ayala and Company, Macabebe, Pampanga Province, Luzon.

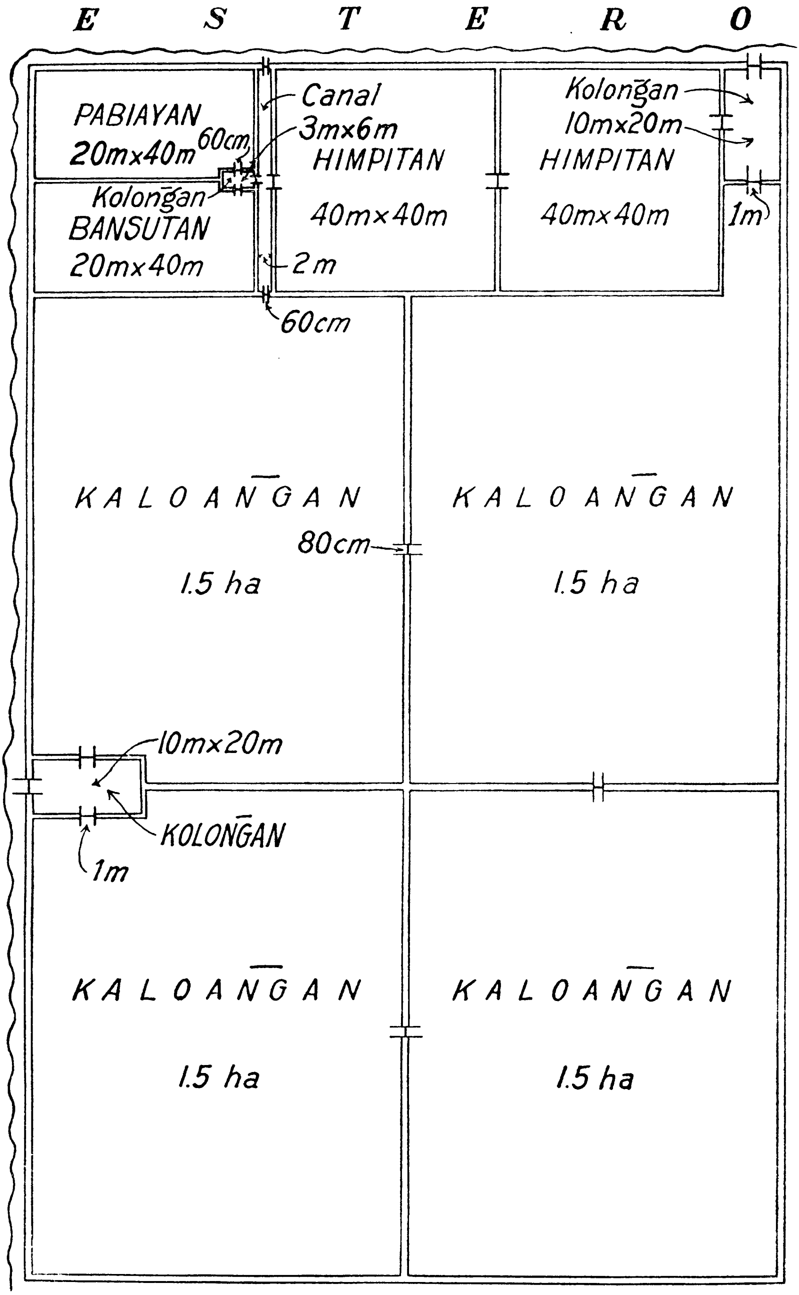

FIG. 5. Plan of an 8-hectare fishpond system, showing the various parts.

algæ, mostly small species of Oscillatoriaceæ; it also contains a great variety of diatoms, bacteria, some unicellular green algæ, and a small proportion of very fine threads of Chlorophyceæ, or filamentous green algæ, such as *Cladophora, Spirogyra,* and *Chaetomorpha.* It also contains many Protozoa, minute worms, and small Crustacea.

The nursery pond is first drained, cleaned, and allowed to dry for at least two weeks. During this time all enemies of bañgos fry should be removed or killed. When the pond is sufficiently dry, water is turned in to a depth of 10 centimeters. After three or four days a growth of lab-lab will be seen on the bottom of the nursery pond. This increases very rapidly until it forms a dense thick mat over the entire floor. The water is gradually increased in depth to approximately 25 centimeters. If the water is any deeper than this, the fry become exhausted diving to feed on the lab-lab attached to the bottom. The water in the nursery pond should be kept clean and fresh, and the pond should be so constructed that the water can be changed rapidly. It should be changed at every tide or at least once a day.

As the water is deepened in the nursery great patches of lab-lab are buoyed up and float to the surface, carrying more or less soil with them. The quantity of lab-lab detached and floating varies with the depth of the water and its temperature.

CARE OF THE BAÑGOS FRY

The nursery pond should be all ready to be occupied when the jars of fry are delivered. To place the fry in the nursery, a jar is set in the water, tilted to one side, and the pond water allowed to flow gently into the jar. The jar is then slowly and carefully turned over until the fry can swim out.

The temperature of the water in the nursery pond is a matter of great importance. It must be cool and should be the same temperature, as nearly as possible, as the water in the jar. As the jars are made of unglazed earthenware the constant evaporation of water through their pores keeps the water inside them cool. Late afternoon or early morning is the best time for putting fry in a pond.

The first three or four days that the fry are in the nursery constitute the most critical period. If heavy rains fall during that time the surface temperature of the pond water drops very suddenly while the saltier water near the bottom is much warmer. This condition makes the fry sick and at such times

the mortality may be as high as 80 per cent. When the rainfall is heavy, pieces of floating lab-lab are dashed about or are carried under by the falling water, crushing many of the fry. Overstocking the nursery pond is the commonest mistake made. One hectare of pabiayan with a good growth of lab-lab can support 300,000 bañgos fry. The bansutan should not have more than half or two-thirds as many, as the fish are larger. More than this number will deprive them of the necessary space in which to move about and will soon exhaust the lab-lab. If the fry are too crowded many of them die.

The nursery pond must be carefully watched to prevent the entrance of enemies. Water snakes (*Chersydrus granulatus*), calabucab in Tagalog, and various kinds of sea-snakes (species of *Disteira* and *Lapemis*), malabasan in Tagalog, commit great depredations. The presence of certain fishes is also a serious matter. Apahap (*Lates calcarifer*), bid-bid (*Elops hawaiiensis*), biang puti (*Glossogobius giurus*), talimosak (*Preiophthalmus barbarus*), tamindak in Visayan, and where the water is only slightly brackish dalag (*Ophicephalus striatus*) and liwalo or puyo (*Anabas scandens*), devour the helpless fry wholesale. A few snakes and a shoal of any of the above fishes will soon devour every young bañgos in the nursery.

Some birds, such as herons and kingfishers, are also very serious enemies of bañgos fry. Fishhawks and eagles are fond of bañgos and will catch and eat the marketable fish. It is often necessary to post a watchman armed with a shotgun to kill or scare off the birds, especially around the newly established fishponds.

Many fishpond owners, especially around Malabon, Navotas, and Obando, use their ponds exclusively for nursery purposes. They carry the fry through the critical early stages and sell them later to growers whose ponds are in less-favorable localities in Pampanga and Bataan Provinces.

If the conditions in the nursery pond are all favorable, the bañgos fry grow rapidly and should be 40 to 50 millimeters in length in from four to six weeks. After they are 35 millimeters or more long they are called "hatirin," or "pawalain" in some parts of Bulacan, and are ready to be transferred to larger ponds. Hatirin still feed somewhat upon lab-lab but begin to feed upon lumut or filamentous green algæ, and as they grow cease gradually to eat lab-lab.

One of the most-marked characteristics of bañgos is their instinct to swim against a current. Advantage is taken of this

in moving them, as without this habit it would be difficult to catch them when small and delicate, without injuring many. When water is admitted through the sluice gate at high tide bañgos, no matter how small, meet the inflowing current and crowd against one another in it, frequently jumping in the air against the flow of water.

A large fine-meshed net (panagap), 6 or 8 meters long and 3 or 4 meters wide, but narrower at the bottom than the top, is used to surround the fish after they are gathered in the current. The hatirin are now scooped up in two large square dip nets (bitinan), half the quantity of young fish in each. The fish are not lifted from the water, but the bag of the dip net is kept down so that the fish are always under the water. Each dip net is supported by a bambooo pole at each corner, and the poles are stood up vertically in the pond.

The contents of each dip net are again divided in the same way between two dip nets, and this process is continued until the number left can be counted easily, care being taken to keep the fish under the surface of the water. The total number of fish is obtained by doubling the count in the last net, and then doubling for each division made before.

The fish can be very easily transferred to another division of the same pond. One man takes hold of each pole, and the others carry the net along keeping its bag down so that the fish are always under water.

When the hatirin have to be transported longer distances a large clean banca is used. The boat is partly filled with clear salt water, and the fish are placed in it. A screened hole in the banca provides circulation of water, and men bail constantly to keep the boat from sinking. If the distance is very great the banca is towed by a motor boat. The transfer of hatirin should be done during the coolest part of the day or, if possible, at night.

Sometimes large hatirin are caught by draining the pond until there is no water left except in the ditch through the center and around the margin. The hatirin are then dipped up in a fine-meshed net.

The current price of hatirin is from 65 to 125 pesos a lacsa, depending upon their size and vitality, and the distance to be transported. They are shipped during May, June, July, and August.

A hectare in a first-class pond used as a himpitan will carry 10,000 hatirin for a short time until the large pond is ready.

GROWING LUMUT, OR ALGÆ

For convenience, the word "lumut," widespread in the Malay languages, will here be used as a synonym for "algæ."

Before hatirin are placed in a pond it should be drained and left dry for from three days to a week, depending upon the weather. All snakes, mud skippers, and other enemies should be destroyed. Then the water should be turned in to a depth of about 10 centimeters, which will start lumut growing all over the bottom of the pond, in small rounded bunchy patches. As the lumut gets larger, the depth of the water is gradually increased. The little hatirin nibble away at the young lumut, but if the proportion of fish is correct there will be sufficient feed for a time. In the meantime the large pond or ponds should be prepared in the same way with a fine growth of lumut, for hatirin are only kept in the first small-sized pond until the large one is ready for them.

In some places where the soil conditions are not very favorable, it may be necessary to grow lumut by transplanting. First the pond is drained and well cleaned as previously described. Then water is turned in again to a depth of 10 centimeters and clumps of lumut are planted. As soon as new growth begins, the depth of water in the pond is steadily increased until the normal depth is reached. By that time there should be sufficient growth of lumut so that fish may be turned into the pond.

Under favorable conditions the growth of lumut may be so luxuriant that some of it must be removed to give the fish room to move about freely. The same result is obtained by putting in lines of stakes and crowding the lumut behind them, thus making lanes of clear water in which the fish can swim.

On the other hand, during the rainy season the mud carried into the pond and the reduction of the salinity of the water by prolonged heavy rains seriously check the growth of lumut. The mud is deposited upon the young algæ springing up on the bottom and checks its growth or kills it. An excessive amount of fresh water coming in contact with algæ in salt-water ponds may plasmolyze the filaments and destroy the plants. When this happens on a large scale the ignorant laborer sometimes says that fresh water kills the bañgos. What really happens in such cases is that the fish starve to death because the algæ have been killed by the fresh water.

In ponds subject to flooding by fresh water or where the salinity becomes much reduced, especially during the rainy season,

there is sometimes difficulty in keeping down the growth of grass in the pond itself. When other means fail the bottom of the pond where the grass grows is scraped off to a depth of about 10 centimeters. The mass of grass and roots is then thrown into the river, to be carried away.

The fish are too crowded in the hatirin pond to make the rapid growth that comes later in the large pond. The hatirin are usually kept two or three months in the pond to which they were first transferred. They are then 75 to 100 millimeters in length and are called "garoñgin." In some parts of Bulacan they are called "bansut."

GAROÑGIN

Some people keep garoñgin in small ponds with an ample supply of fresh sea water but with very little lumut for six or seven months. They then sell them at a high price to people who wish to stock their ponds and produce marketable bañgos out of the usual season.

Where fishponds are easily cleaned and there is little or no danger of the fish being eaten, the hatirin are turned at once into the large pond, called in Tagalog "kaloañgan," or "spacious." The other method is to hold the hatirin in a small pond, called "himpitan," or "small space," as already described, until the hatirin are large enough to be in no danger from ordinary enemies.

STOCKING THE LARGE BAÑGOS POND

The number of fish per hectare in ponds stocked for market depends upon the condition of the pond. The usual practice is to overstock. Carefull growers when making the final allotment usually put in 1,000 hatirin for each hectare of pond in good condition. A pond in excellent condition where everything is favorable, as the Ayala ponds at Macabebe, Pampanga, can carry from 1,500 to 2,000 hatirin or garoñgin per hectare till ready for market. We believe that as a rule beginners will obtain better results with a smaller number and therefore recommend that in making the final distribution 800 to 1,000 hatirin be allowed for each hectare of pond with a luxuriant growth of lumut. Then if a grower finds by experience that his pond can safely carry more he can gradually add more young fish until he finds the limit his pond can feed.

Heavy losses or even failure result from overstocking. Many owners know that their pond will not support the large number of fish that they place in it. They say many are going to die, and they have the foolish notion that if they put in a great many they will have more left than if they put in a smaller number. Accordingly they put in five, six, eight, or more thousand young fish for each hectare and of course they die wholesale. There have been cases where unthinking people have put as many as 30,000 hatirin in a hectare. Of course, the more they put in the higher the percentage of deaths. Even if a pond is only slightly overstocked the supply of lumut is soon exhausted, and the undernourished fish crowd one another so that they do not have room to exercise and develop properly.

Sometimes a fishpond owner attempts to supply the lack of food in his pond by buying lumut. As bañgos are voracious feeders it is difficult to buy enough lumut to feed them, and the cost at 5 pesos a banca load may soon exceed the normal profit. Others who have overstocked or whose ponds are without a good growth of lumut are compelled to sell their bañgos long before they are large enough to bring a profitable price.

Garoñgin 10 centimeters long should reach marketable size in from two to three months after being turned into a large fishpond with all the conditions favorable. Garoñgin can be transferred from pond to pond in the manner already described for hatirin, but usually they are handled in a different way.

The garoñgin are led into a small catching pond by causing a stream of water to flow from it. Naturally they swim against the current, and as soon as they have passed in the gates are closed. A long net or mat of split bamboo, about 12 meters long and 1.5 meters wide, is used to surround the garoñgin in a semicircle or horse-shoe form inclosing the gate. This semicircular shape is called a "garong" and the name "garoñgin" for the fish inclosed is derived from it. The garoñgin are taken up from the garong with dip nets and counted as they are turned loose in the final pond.

There is no fixed time for putting hatirin or garoñgin in the final stock pond. Whenever one has a pond in proper condition and can get strong healthy hatirin or garoñgin is the time to plant. The best time to plant is during the dry season, as weather conditions are more favorable then and it is easier to keep enemies in check.

FOODS PLANTS OF BAÑGOS

The diet of bañgos under normal fishpond conditions is almost exclusively composed of filamentous green algæ or lumut, belonging to the Chlorophyceæ. As previously explained, the fry feed at first upon lab-lab but gradually change their feeding habits until they feed only on lumut.

The principal algæ growing in the bañgos ponds about Manila Bay are various species belonging to the genera *Cladophora, Enteromorpha, Spirogyra,* and *Vaucheria.*

The blackish .green patches or masses of *Enteromorpha* are conspicuously different in color and general appearance from *Cladophora* or *Spirogyra.* These algæ may form a nearly solid growth of green to yellowish green, matted and more or less floating entanglements, while *Vaucheria* creeps over the bottom in dense felted masses which rise only part way to the surface. *Spirogyra* is exceedingly slippery to the touch and in this respect contrasts strongly with *Voucheria,* which feels like coarse wet cotton.

Where conditions are favorable these algæ grow in dense masses over large areas, frequently almost completely filling the pond.

Various hydrophitic flowering plants also occur in bañgos ponds, and the general name "digman" is applied to all of them. *Ruppia graminea* var. *rostrata* Agardh, *Nejas graminea* Delile, *Halophila beccarii* Aschers, *Halophila ovata* Gaudichaud, and *Thalassia hemprichii* (Ehrenberg) Aschers are found in fishponds, and all are included under the name "digman." Some species of *Ruppia* do well in sea water, but most kinds of digman thrive best in the rainy season when the salinity of the ponds is reduced. Sometimes the growth of digman becomes so luxuriant during the rainy season, especially in July and August, that there is hardly room left for the fish and it becomes necessary to have some pulled out by the roots. *Halophila beccarii* occurs only in salt-water ponds, sometimes entirely covering the bottom, rooting in and creeping over the mud and remaining entirely submerged.

When the salinity of a pond has been very greatly reduced duckweed, or lia, *Lemna paucicostata* Hegelmaier, may appear and increase till it nearly covers the surface of the pond. The presence of *Lemna* under such conditions is an indication that the pond is not in good condition, and that dalag are probably

present. The pond should be restored to good condition by having the salinity raised to normal. The *Lemna* itself is not harmful and bañgos eat its roots greedily.

When bañgos are sick they usually scatter, instead of swimming in groups or small schools. They become sluggish, whereas healthy bañgos are noticeable for their quick movements. If the body looks thin, the head too large for the body, and the base of the pectoral fin becomes whitish, they are not getting enough to eat. At such times *Lemna* is given them as "medicine," but all the medicine they need is plenty of lumut or digman. When the pond cannot supply enough food, some people soak tikitiki (rice bran) over night till it sticks together, then put it on the bottom of the pond in small mounds for the bañgos to eat. Others throw horse manure into the pond and say the fish like to eat it. However, the fish are so hungry they will eat anything. When there is not enough lumut in a pond bañgos will eat all the grass projecting from the dikes into the water, and will even stick their heads out of the water to reach grass on the bank.

ONE CROP OR TWO CROPS A YEAR

Harvest time in bañgos ponds varies widely according to the management and also the locality. There are two plans in general use; namely, harvesting once a year and harvesting twice a year. To say that the bañgos are marketed but once a year is a misstatement, since under this system they are really harvested from the end of May to the close of the rainy season in September. When the fish are taken from a pond it is drained and a new growth of lumut started unless the pond already has a luxuriant growth of algæ. It is then promptly restocked with the requisite number of hatirin or garoñgin, so that very little time is lost from the use of the pond. The bañgos harvested under this method weigh from 400 to 600 grams, with an average of 500 grams, and sell at from 25 to 42 centavos each, according to the state of the market.

Occasionally a few bañgos escape when the rest are harvested and remain uncaught for another year. By the end of the second year they will weigh between 1 and 2 kilograms. Such bañgos are called "laón."

When the owner follows the method of harvesting bañgos twice a year hatirin are placed in the pond during May or June and marketed from the end of September through the month of October. Then the pond is drained, the ground freshly pre-

pared, and the pond restocked with garoñgin which are harvested in April and May. The bañgos reared under this method should reach a weight of 300 to 500 grams and sell for 20 to 35 centavos each.

Under this plan the owner should keep a himpitan well stocked at all times with hatirin or garoñgin, ready to place in large empty ponds whenever they have been cleaned and have enough algæ to support the proper number of fish. Some owners keep two sizes of bañgos in a given pond. Then when the larger ones are marketed a coarse-meshed net is used which permits the smaller ones to escape. After those of large size have been removed hatirin or garoñgin are added to take the place of those marketed, those that escaped the net being sold in their turn a few months later. This operation can be continued as long as the pond remains clean and the algæ continue to grow luxuriantly. Whenever foul mud accumulates on the bottom of the pond or algæ fail to grow properly the pond should be drained and sunned, and a fresh growth started as previously described.

Each method of growing and marketing bañgos has advantages, and a fishpond owner must determine for himself which is better under the conditions in his locality. In general the better plan is the one that keeps down overhead expenses and labor costs without unduly reducing the income.

When bañgos are harvested but once a year they naturally bring a higher price because they are larger than those four to six months younger. Labor and transportation costs are also much less under this plan. In spite of these facts, harvesting the bañgos twice a year is the more profitable method if the pond is first class in every way and marketing conditions are favorable. Another point to consider is the greater salability of small bañgos. The common people are the chief users of bañgos, and their purchasing power is low; until their economic status is much improved it will continue to be easier to sell three small fish than a larger one costing twice as much as one of the others.

The weight that a bañgos should attain within a given length of time is unknown, and there are many factors that help determine the rate of growth. Some of the more important of these are the following:

The rate of renewal of the pond water, or the time elapsing between changing the stale water with clear fresh tidal water of the proper salinity.

The circulation of water within the pond system.
The amount of rainfall.
Sudden variations in salinity.
The character of the soil forming the bottom of the pond.
The kind, the quality, and the quantity of food available per fish.
The size and the depth of the stock ponds.
The number of fish to the hectare.
The number of bubuntis or other fishes living upon the same kind of food as that eaten by bañgos.

THE CATCHING POND, OR KOLOÑGAN

As previously stated, a large fishpond system should have a small division where the marketable fish may be caught. In systems containing only a few hectares any of the smaller divisions may be used for this purpose, or a nursery pond may serve as a koloñgan if it is without fry.

The koloñgan should adjoin the main stock pond, and is often built either at its exit or around the outlet or main sluice gate of the whole system. It should be well provided with gates, in order to control the flow of water equally well in either direction.

CATCHING MARKETABLE BAÑGOS

During high tide, water from the outside is allowed to flow into the fishpond where the marketable bañgos are. As soon as the fish feel the current they begin to swim against it until they reach the catching pond. They become so eager to force their way against the incoming current that they bump their snouts against the grating of the gate, crowd one another half out of the water, and even leap high in the air.

As soon as all the bañgos or as many as are wanted have entered the catching pond the sluice gates between it and the other ponds are closed. The fish should then remain in the koloñgan at least twenty-four hours before being caught. By that time the intestinal tract will be empty, and they will keep very much longer than when caught at once while full of food.

When sufficient time has elapsed, a large seine is dragged across the koloñgan from end to end or one side to the other. During this operation there is great excitement. As the fish become crowded they dart to and fro with great speed or leap high in the air. Frequently they jump clear over the net. I have seen them leap at least two meters above the surface of the water, passing high above the net. Usually the seine is hauled to the bank and lifted section by section, the captured

fish being placed in a banca. The pond is swept several times by the seine until all or practically all the bañgos are caught. Some ponds have a runway at the lower end into which the fish are driven by the net, which finally closes the upper end of the runway, or the runway may be closed by a sluice gate at each end. The densely crowded fish are then easily lifted out by long-handled dip nets.

If the bañgos are placed in a banca they are transferred to large baskets when the boat is brought to the shore. The fish are then laid out and sorted into the standard sizes. All fish of other kinds, such as apahap, banak, bia, bid-bid, kitang, and the like, if any have been caught, are also placed in separate piles.

After the bañgos have been sorted ten or a dozen should be taken from each pile and weighed. The weight obtained is divided by the number weighed to get the average weight. This, multiplied by the total number in each pile, is taken as the weight of all the bañgos in each group. Every progressive fish-pond owner who wishes to keep a careful account of his income and expenses, profits and losses, should weigh his fish. As a matter of fact most owners do not do it.

Sometimes when the incoming water is muddy or not clear the bañgos refuse to swim against it, and then of course cannot be lured into the catching pond. The fishpond owners also believe that bañgos which have escaped from the koloñgan, or which have bumped their snouts against the wall or sluice gate when swimming against the current, have more or less influence over the rest and lead them away from the koloñgan.

When the fish will not go into the catching pond they are caught by dragging a seine across the kaloañgan, or large pond. This is a very poor method. The fish are full of partially digested food, which decays rapidly, causes the fish to have a bad odor in a short time, and lowers their value and salabity.

The fish should be caught for market late in the evening or at night, so that they will be in good condition in the market the following morning. Around Manila Bay the large producers put their bañgos in a motor boat, or in a large banca towed by a launch, and rush them to Manila, reaching there about 4 o'clock in the morning. Producers along the coast of Bataan Province pack their fish in ice and ship them to Manila on small local steamboats. Fish from ponds at the more-interior points in Bulacan and Pampanga Provinces and near railway stations are packed in ice and shipped by rail to adjacent provinces

such as Tarlac, Pangasinan, Nueva Ecija, and Laguna. Some bañgos are also shipped by truck to neighboring towns. Generally bañgos packed in ice bring a lower price than fish not iced.

In some regions, especially in Panay, several ingenious methods are in use for the capture of marketable fish. In the vicinity of Barotac Nuevo the following method is used: Two small inclosures, each about 2 meters wide and 4 meters long are built adjoining one corner of the main pond, after the manner of the diagram in fig. 6. During high tide the gates A, B, C, and D and also baklad 2, 3, and 4 are opened, leaving only baklad 1 closed. Water accordingly flows freely into the

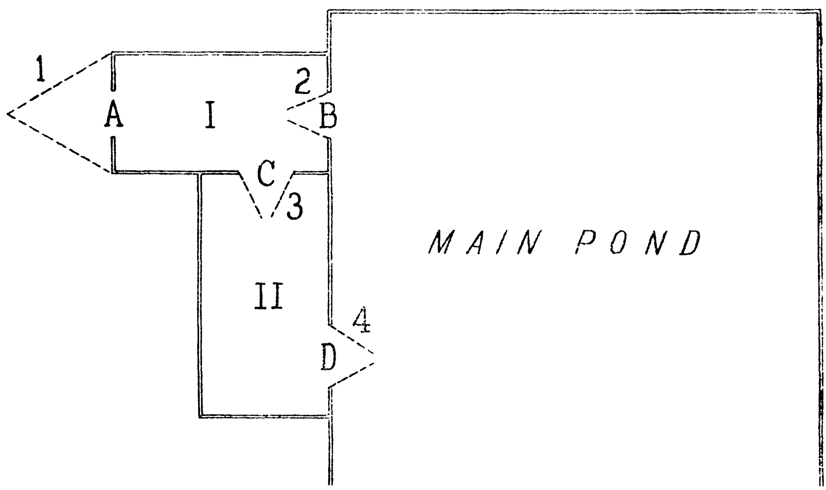

FIG. 6. Plan of a fishpond and small catching ponds used at Barotac Nuevo, Iloilo Province, Panay.

pond, and the bañgos swimming against the current enter catching pond I, through gates B, D, and C, after which all the gates are closed. At low tide gates C and D are opened, but baklad 4 is kept closed. The fish in compartment I will then swim against the current flowing through C and D and enter compartment II, after which gate C is closed. From compartment II the bañgos may be taken by a net in the manner already described.

This is a clever scheme as it leaves compartment I free to be utilized for any purpose needed. The baklad can likewise be used for catching shrimps and for fishes other than bañgos.

Compartments I and II are too small for a fishpond system of much size, but this is a matter of detail easily adjusted.

Another method, generally used in Java and widely current in the Visayas, is to construct a baklad in the main pond, around the inner side of the sluice gate; sometimes it may be placed in the canal or creek outside the gate. If the baklad is outside the pond, the gate is opened at high tide when it is desired to catch fish. The bañgos swimming against the current pass through the gate and enter the baklad. As soon as the tide turns and the current slackens, the gate is closed, leaving the fish in the center of the baklad. From this they are easily removed with a long-handled dip net. This is an excellent method for small ponds or for catching limited quantities of fish, but is not adapted for the handling of large numbers of bañgos.

When the baklad is within the pond, doors are opened in the baklad through which the fish can enter it at high tide. These doors are closed at low tide, thus confining the fish within the baklad.

All the above methods are subject to many variations, but the principle in each is embodied in those outlined above.

BAÑGOS PONDS IN JAVA

I have recently had the privilege of examining the methods of bañgos culture now in use around the city of Batavia, Java. The industry is much more extensively developed in the vicinity of Samarang, Surabaya, and on Madura Island, but my stay in those places was too brief to permit of an examination of the fishponds there.

The bañgos industry in Java is entirely in the hands of Chinese, and the ponds are located in the nipa and mangrove swamps along the coast. Three hundred years ago the territory now occupied by fishponds at Batavia, between Pasar Ikan and the open sea, on both sides of Kali Besar, was all open water. The land has been built up during that time for 1 to 3 kilometers beyond Pasar Ikan, by the encroachment of mangroves upon the sea.

In general, the bañgos ponds were well laid out and conveniently arranged, but in no case were the sluice gates or principal gates solidly constructed of permanent or durable material, such as stone or concrete. The ponds were not as well kept as the ponds about Malabon, and the general practice of fishpond management in Rizal, Bulacan, and Pampanga Provinces is much superior to anything I saw around Batavia.

The ponds themselves are well constructed but the small, cheaply built sluice gates, and gates within the system, give an

air of cheapness and shabbiness, compared to the large, strong, handsomely made concrete gateways seen in the better class of ponds about Manila Bay.

Many of the ponds have a small baklad on the inner side of the gate, so that when water is allowed to enter the bañgos swimming against the current can be caught in the baklad, dipped out, and sent to market.

Apparently no ponds are provided with special inclosures for catching marketable bañgos. The usual method of catching bañgos is as follows: At each end of a pond a row of fishermen is stationed, each man provided with a cast net. Stepping into the water and wading slowly forward in line, each man throws his net whenever he sees bañgos or the water moved by fish. All fish caught are placed in a bag trailed behind. The escaping fish rush back and forth between the advancing lines; now and then some rush past the men and escape behind. When the rows of men are near each other a gill net is stretched upright across the pond behind each file of fishermen. The fish rush wildly to and fro in their efforts to escape, frequently leaping high into the air and occasionally vaulting clear over a gill net; others rush headlong into one of the gill nets. It there are many fish the scene is often very exciting. The fishermen have their cast nets in operation all the time, and their shouts and splashing add to the wild frenzy of the terrified bañgos.

When the fishermen are not able to catch enough to make it worth while they go back to their respective stations at the ends of the pond, which is then gone over in the same manner a second time.

OTHER FISHES FOUND IN BAÑGOS PONDS

As already explained, it is very difficult to prevent the entrance of other kinds of fishes into bañgos ponds. Not only are certain kinds found mixed with the bañgos fry in the palayok, as previously set forth, but the young of many other kinds pass through the meshes of the bamboo screens when fresh salt water is admitted at high tide.

Often the sluice-gate tender is careless, and leaves the outer bamboo screen up so that the space next the river is entirely open. Careless workmen may let the outer screen down only when water is admitted at high tide. This should not be tolerated. Manifestly any fish lurking about could dart through when the boards of the solid gate are lifted to let in the fresh tidal water. Large fish of certain kinds, such as dalag, are

able to eat hatirin and even garoñgin and often produce eggs at once, which soon hatch into a horde of ever-hungry carnivorous fish that are terribly destructive in a nursery pond.

If the boards of the central partition do not fit tightly, or have small holes in them, the fry of many carnivorous fishes may enter if the outer bamboo screen is left up. The outer bamboo screen at least should be kept lowered at all times.

If the pond is near a bay or other large body of salt water, bubuntis, bia, or gobies of many kinds, several kinds of eels, banak, ambassids, or langaray, kitang, buan-buan, apahap, talakitok, sap-sap, halfbeaks, and ayuñgin are found in greater or lesser abundance. If the pond is at some interior point where it may be flooded by fresh or only slightly brackish water it will be very difficult to keep out dalag and liwalo, two very dangerous enemies.

The fish of greatest abundance in bañgos ponds, after bañgos itself, is a small fish, *Mollienisia latipinna* Le Sueur, belonging to the family Poeciliidæ, which was inadvertently introduced from Hawaii. It is a viviparous fish, with strongly differentiated sexes; the female produces from fifty to seventy-five living young at a time. The Tagalog name of this fish is "bubuntis," meaning "pregnant," because of the deep protuberant belly of the female.

Bubuntis feed upon lab-lab, and therefore compete with bañgos fry, and when abundant greatly reduce the amount of food available for the bañgos fry. As the adult male bubuntis is never more than 40 millimeters in length, and a female never more than 48 millimeters long, they are too small to be valued as food in the fishpond districts. In the Philippines any fish visible to the naked eye is usually considered good food if it can be obtained in quantity. Bubuntis is an exception to this, because its flesh is bitter.

Bubuntis occur in enormous numbers in bañgos ponds, especially those of high salinity. They thrive in the ponds where salt is made, being able to enjoy life where no other Philippine fish can exist. We have obtained them in ponds where the salinity was 8.3 per cent, or nearly three times the normal salinity of Manila Bay. I have seen schools of bubuntis of at least twenty-five thousand individuals in the catching pond of a bañgos-pond system. With the large dip net used for catching young bañgos five to ten thousand bubuntis were taken up at a single scoop.

The only way to get rid of bubuntis is to drain, clean, and dry the pond. They are abundant in the salt-water tidal creeks

along the border of Manila Bay. It will probably be impossible to prevent them from entering with tidal water.

Bid-bid and buan-buan are swift, rapidly growing, voracious, carnivorous fishes distantly related to bañgos. As already stated, they are often caught with bañgos fry and are mixed with them in the jar. Buan-buan also enter fresh-water rivers and lakes and frequently enter bañgos ponds when water is admitted through the gratings in the sluice gates. Every effort should be made to keep them out as they devour many fry and hatirin.

Gobies, or bia, of many kinds occur in fish ponds and all of them are injurious to young bañgos. After the fry have reached the garoñgin stage they are in no further danger from gobies.

The commonest, largest, and most-dangerous goby in fishponds is *Glossogobius giurus*, or biang puti. It is very abundant in both salt and fresh water, and usually, if not always, spawns in the sea. The young ascend rivers in schools, and some of them are almost sure to gain entrance through the sluice gates of fishponds. If they get into a pond of fry or hatirin they devour them wholesale. Biang puti are readily salable in the market, and if taken from a pond of bañgos too large to be injured may be considered as clear gain, but if they have been feeding upon bañgos fry their presence is a distinct loss. Another goby dangerous to fry is the mud skipper, or talimosak, already mentioned. Names the gobies more or less abundant in fishponds are given on pages 494 and 495.

Many kinds of small eels frequent fishponds and are very destructive to fry and hatirin. Most of them are snake eels, belonging to the genera *Pisodonophis* and *Ophichthus*. One of the rice-paddy eels, *Synbranchus bengalensis*, is also abundant in bañgos ponds. Fortunately an eel related to the conger eels, *Muraenesox cinereus*, is not so common, as it is very voracious, grows to a large size, and is able to eat marketable bañgos.

When the fishponds are drained many hundred eels and equally large numbers of the smaller kinds of gobies are often taken and sold in the Manila market.

Several kinds of banak, or mullets, enter fishponds. Mullets are strictly vegetarian, living largely upon the organisms contained in the surface layer of mud at the bottom, as well as upon algæ. They do no harm to bañgos and are better food fishes.

One of the worst enemies of bañgos is the apahap, a member of the sea bass family. Apahap grow to a large size, and in a pond that has not been drained for a couple of years they may be a meter long, able to devour bañgos of marketable size. Apahap are of very fine quality as food and always bring a high price in the market, but they are an expensive luxury for the proprietor of a bañgos pond since they gobble large numbers of bañgos at all stages of growth.

Kitang are well-flavored fish abundant in rivers and estuaries and are sometimes found in fishponds. As they are vegetarian or scavengers they cannot harm the bañgos and their presence is not objectionable.

Halfbeaks are also harmless unless they obtain entrance to the nursery pond.

Ambassids, or langaray, are small translucent fish that occur in enormous numbers in rivers near the sea and tidal creeks. They are very destructive to kawag-kawag if they obtain entrance to the nursery pond, and are also harmful to hatirin. They are harmless to bañgos fry 40 millimeters or more in length.

Now and then a few talakitok, or pampanos, enter a fishpond. They are very fine food but are destructive to bañgos in the kawag-kawag, hatirin, and garoñgin stages.

Ayuñgin occur in both fresh and salt water. A few in a nursery pond would devour a great many fry. However, they are not abundant in fishponds, as a rule, unless the salinity is reduced, as in the rainy season.

If the water in a fishpond has its salinity greatly reduced, or is exposed to freshets or floods of fresh water in the rainy season, dalag will be almost sure to enter. Dalag are not only very active but during the rainy season leave streams and wander about on land wherever there is a trickle of water. They easily leap upon or over low dikes, when their actual height has been reduced by floods or high water. Only high well-kept dikes, free from holes or leakage, will keep out dalag. Fortunately they cannot live long in sea water of normal salinity or above. Therefore, the best preventative of dalag is to keep the water in the ponds up to normal salinity. Then those which enter will not be able to do much harm and will soon become blind and die shortly after.

Where it can survive, the dalag is one of the most dangerous enemies of bañgos. A few dalag in a nursery pond will soon

eat every kawag-kawag in it. No effort should be spared to keep dalag out of bañgos ponds.

Liwalo or puyo, the climbing perch, is also a serious menace in bañgos ponds with water of reduced salinity, especially in the rainy season, when few ponds are without them.

Climbing perch can live in saltier water than dalag can, but are not so dangerous to the bañgos grower. They do not reproduce so rapidly or in such numbers as dalag do, and are not so voracious. However, their presence in a nursery pond is a serious matter and they should be exterminated as soon as possible whenever found in a bañgos pond.

The following list includes all the fishes besides bañgos thus far collected from bañgos ponds in the Philippines:

Ambassis kopsi Bleeker; lañgaray.
Ambassis urotaenia Bleeker; lañgaray.
Amia quadrifasciata (Cuvier and Valenciennes).
Anabas testudineus (Bloch); climbing perch; liwalo; puyo.
Anchovia baelama (Forskål); anchovy; dilis; bolinao.
Anchovia mystax (Bloch and Schneider); anchovy; dilis; bolinao.
Arius manillensis (Cuvier and Valenciennes); catfish; kanduli.
Arius thalassinus (Rüppell); catfish; kanduli.
Butis butis (Buchanan Hamilton); goby; bia.
Caranx calla (Cuvier and Valenciennes); pampano; talakitok.
Caranx ignobilis (Forskål); pampano; talakitok.
Chonophorus lachrymosus (Peters); goby; bia.
Cirrhimuraena tapeinopterus Bleeker; eel; palos.
Clupanodon nasus (Bloch); kabasi.
Clupeoides lile (Cuvier and Valenciennes); sardine.
Congrogadus subducens (Richardson).
Creisson validus Jordan and Seale; goby; bia.
Elops hawaiiensis Regan; Jackmariddle; bid-bid.
Evenchelys macrurus (Bleeker); eel; ogdok.
Gerres punctatus (Cuvier and Valenciennes).
Glossogobius giurus (Buchanan Hamilton); goby; bia; biang puti.
Gnatholepis puntangoides (Bleeker); goby; bia.
Harengula fimbriata (Cuvier and Valenciennes); sardine.
Hemiramphus gaimardi Cuvier and Valenciennes; halfbeak; buguing; bayamban.
Hemiramphus marginatus (Forskål); halfbeak; buguing; bayamban.
Lates calcarifer (Bloch); apahap.
Leiognathus caballus (Cuvier and Valenciennes); sapsap.
Leiognathus fasciatus (Lacépède); sapsap.
Leiognathus splendens (Cuvier); sapsap.
Liza coeruleomaculata (Lacépède); mullet; banak.
Liza melinoptera (Cuvier and Valenciennes); mullet; banak.
Liza troscheli (Bleeker); mullet; banak.
Liza waigiensis (Quoy and Gaimard); mullet; banak.
Lutianus chirtah (Cuvier and Valenciennes); snapper.
Megalops cyprinoides (Broussonet); little tarpon; buan-buan.

Mionurus bombonensis Herre.
Mollienisia latipinna Le Sueur; killifish; bubuntis.
Monodactylus argenteus (Linnæus).
Mugil dussumieri Cuvier and Valenciennes; mullet; banak.
Muraenesox cintereus (Forskål); eel.
Muraenichthys gymnopterus Bleeker; eel; palos.
Muraenichthys malabonensis Herre; eel; palos.
Ophicephalus striatus Bloch; dalag.
Ophichthus apicalis (Bennett); eel; palos.
Ophicthus celebicus (Bleeker); eel; palos.
Ophichthus manilensis Herre; eel; palos.
Ophiocara aporos (Bleeker); goby; bia.
Ophiocara porocephala (Cuvier and Valenciennes); goby; bia.
Oxyurichthys microlepis Bleeker; goby; bia.
Oxyurichthys viridus Herre; goby; bia.
Periophthalmodon schlosseri (Pallas); mudskipper; talimosak.
Periophthalmus barbarus Linnæus; mudskipper; talimosak.
Pisodonophis boro (Buchanan Hamilton); eel; palos; pindanga.
Pisodonophis cancrivorus (Richardson); eel; pindanga.
Plotosus canius (Buchanan Hamilton); catfish; alimosang.
Pomadasys hasta (Bloch).
Priopis buruensis (Bleeker); lañgaray.
Pseudorhombus arsius (Buchanan Hamilton); flounder; dapa; palad.
Rhinogobius caninus (Cuvier and Valenciennes); goby; bia.
Rhinogobius viridi-punctatus (Cuvier and Valenciennes); goby; bia.
Scatophagus argus (Gmelin); kitang.
Sillago sihama (Forskål).
Sphyraena jello Cuvier and Valenciennes; barracuda; babayo.
Synbranchus bengalensis (McClelland); eel; palos.
Taenioides gracilis (Cuvier and Valenciennes); snake goby; eel goby.
Tetraodon immaculatus Bloch and Schneider; puffer; botete.
Tetraodon reticularia (Bloch and Schneider); puffer; botete.
Teuthis hexagonata (Bleeker); samaral.
Therapon argenteus (Cuvier and Valenciennes) ayuñgin.
Therapon jarbus (Forskål).
Therapon quadrilineatus (Bloch).
Tylosurus strongylurus (Van Hasselt); gar.
Umbrina russelli Cuvier and Valenciennes.
Upeneoides sulphureus (Cuvier and Valenciennes); goatfish; timbuñgan.
Vaimosa piapensis Herre; goby; bia.
Zenarchopterus dispar (Cuvier and Valenciennes); halfbeak; siliuw.

CRUSTACEA FOUND IN BAÑGOS PONDS

Several kinds of shrimps usually occur in large quantities in bañgos ponds, especially the kind known as sugpó. Small traps, modelled after large fish corals but made especially for shrimps, are placed in the fishpond and the shrimps removed from them by dip nets every morning. As previously stated, shrimps are not harmful if they are not allowed to enter the nursery pond.

Several species of crabs are found in bañgos ponds, and if of the best marketable kind may bring considerable revenue to the fishpond owner. Crabs (alimañgo) of several kinds sell for 20 to 30 centavos each; large females in good condition bring even more. Alimasag, crabs of the genus *Neptunus*, bring a lower price. In regions near the sea the crab called dakomo is very abundant in fishponds and does much damage by burrowing in the banks.

In spite of the fact that crabs may contribute to the income, their presence in a bañgos pond is a source of more expense than revenue. They burrow large holes in the dikes, which must be closed or otherwise the leakage will soon be beyond control. Their holes cause much loss of water, or the entrance of fresh water (not salt), and they allow water snakes, eels, dalag, and other enemies to get into the fishpond.

Another burrowing crustacean very harmful to fishpond dikes is the sea mantis. At least three species of this peculiar group are found in bañgos ponds, requiring frequent patrol of the dikes to keep them in check.

The following Crustacea have been identified from fishponds about Manila Bay and in the Visayan Islands:

Alphaeus sp.; pistol crab.
Goniosoma merguiense de Man; crab.
? *Goniosoma orientale* (Dana); crab.
Gonodactylus scyllarus Linnæus; sea mantis; ulapihan dagat.
Grapsidæ, sp.; crab, kais-kaias.
Lysiosquilla maculata Fabricius; sea mantis; ulapihan dagat.
Metapograpsus maculatus Edwards; crab; grumente.
Neptunus pelagicus (Linnæus); crab; alimañgo.
Palaemon carcinus Fabricius; shrimp; ulang. This is very abundant in water of low salinity. The adults are dangerous to small fish.
Palaemon sundaicus Heller; shrimp; ulang.
Parapeneopsis sp.; shrimp; ulang.
Peneus monodon Fabricius; shrimp; ulang; sugpó.
Peneus semisulcatus De Haan; shrimp; ulang; sugpó.
Scylla serrata (Forskål); crab; kalungkot; alimañgo.
? *Sesarma palawanense* Rathbun; crab.
Sesarma taeniolata White; crab; dakomo. Abundant and very destructive to fishpond dikes.
Squilla nepa Latreille; sea mantis; ulapihan dagat.
Thalamita crenata (Latreille); crab; alimañgo.
Thalamita danae Stimpson; crab; alimañgo.
Thalassina anomala (Herbst); sea scorpion.
Uca acutus (Stimpson) fiddler crab; bangi-bangi.
Uca annulipes (M. Edwards); fiddler crab; bangi-bangi.
Uca dussumieri (M. Edwards); fiddler crab; bangi-bangi.

TECHNICAL DESCRIPTION OF THE BAÑGOS

The ancient family of isospondylous fishes Chanidæ belongs to the suborder Clupeoidei, or herringlike fishes. It contains but one living genus, with only one species of very wide distribution in tropical Indo-Pacific waters. Remains of some extinct fishes have been found in Cretaceous, Eocene, and Miocene beds that are classified in this family and assigned to the genera *Chanos* and *Prochanos*.

Body elongate, moderately compressed, and pointed at both ends, with a broad rounded abdomen; head naked, with a large, transparent, imperforate, adipose eyelid covering eye and side of head; trunk covered with firm, closely adherent, relatively small or medium-sized silvery scales; dorsal and anal each with a broad basal sheath; pectoral with a long pointed axillary scale above and below; ventral with a pointed axillary scale above; small scales extend upon the caudal; snout depressed; mouth small, terminal, transverse, and toothless; lower jaw slightly included, with a symphysial tubercle which fits into a notch in the upper jaw between the premaxillaries; the maxillaries short and broad with no supplemental bone; premaxillary joined to the upper anterior edge of maxillary; ventrals well developed, opposite the posterior half of dorsal; anal very much smaller than dorsal and placed very far back; caudal large, deeply forked; lateral line straight, each scale with a single tube; gill membranes entirely united below and free from the isthmus; four long branchiostegals; pseudobranchiæ well developed; gill rakers exceedingly fine, numerous, and close set, in two diverging rows; an accessory branchial organ in a cavity behind the gill cavity proper; air bladder divided by a constriction into an anterior and posterior portion; mucous membrane of the œsophagus raised into a spiral fold; pyloric appendages numerouus; intestine very long and with many convolutions, the peritoneum black.

The fishes of this family are large and have the general appearance of a very large cyprinid; they are found throughout the warmer parts of the Indo-Pacific Ocean. The synonymy of the one living genus of this family follows.

Genus CHANOS Lacépède

Chanos LACÉPÈDE, Hist. Nat. Poiss. 5 (1803) 395.
Lutodeira VAN HASSELT, Ferrusac, Bull. general Sciences 2 (1824) 92.
Ptycholepis RICHARDSON, Ann. and Mag. Nat. Hist. I 11 (1843) 489.

The characters of the single genus are included in those of the family.

In the Zoölogy of the Erebus and Terror, Fishes, Sir John Richardson states on page 58 that he and not Mr. Gray is the author of the name *Ptycholepis*. The usual reference of *Ptycholepis* to Gray, 1842, seems to be a mistake. The second volume of Dieffenbach's Travels in New Zealand, in which Gray's description appeared, was published in 1843. Richardson says:

> This subgenus . . . already been named by me in a Report on the Ichthyology of New Zealand, read at the Meeting of the British Association in June 1842, and in the Appendix to Dr. Dieffenbach's account of New Zealand.

Following is a list of the technical names that have been applied to the only known species of the genus and a technical description of the species.

CHANOS CHANOS (Forskål).

Mugil chanos FORSKÅL, Descript. Animal (1775) 74; BLOCH and SCHNEIDER, Syst. Ichth. (1801) 116.

Mugile chani BONNATERRE, Encyclop. meth., Ichthy. (1788) 180.

Mugil salmoneus (Forster) BLOCH and SCHNEIDER, Syst. Ichth. (1801) 121; FORSTER, Descript. Animal, ed. Lichtenstein (1844) 299.

Chanos arabicus LACÉPÈDE, Hist. Nat. Poiss. 5 (1803) 396; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 135.

Palah bontah RUSSELL, Fishes of Coromandel 2 (1803) pl. 207.

Tooleloo RUSSELL, Fishes of Coromandel 2 (1803) pl. 208.

Lutodeira indica VAN HASSELT, Algem. Konst. en Letterb. (1823) 333; Bull. Sci. Nat. (Ferussac) 2 (1824) 92.

Lutodeira chanos RÜPPELL, Atlas, Fische rothen Meers (1828) 18, pl. 5, fig. 1, *a* and *b*.

Cyprinus (Leuciscus) palah CUVIER, Regne Animal, ed. 2, 2 (1829) 222, after Russell.

Cyprinus tolo CUVIER, Regne Animal, ed. 2, 2 (1829) 222, after Russell.

Leuciscus zeylonicus BENNETT, Proc. Zoöl. Soc. London (1882) 184.

Leuciscus (Ptycholepis) salmoneus RICHARDSON, Ann. and Mag. Nat. Hist. I 11 (1843) 489; GRAY, in Dieffenbach, Travels in New Zealand 2 (1843) 218.

Chanos mento CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 141.

Chanos chloropterus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 141; KNER, Reise Novara, Fische (1865) 341.

Chanos nuchalis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 142.

Chanos orientalis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 143; EYDOUX and SOULEYET, Zoöl. Voy. Bonite, Atlas, Poiss., pl. 7, fig. 1; KNER, Reise Novara, Fische (1865) 341.

Chanos cyprinella CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 144.

Chanos lubina CUVIER and VALENCIENNES, Hist. Nat. Poiss. **19** (1846) 145, plate 533; GÜNTHER, Cat. Fishes **7** (1868) 474; BLEEKER, Atlas Ichth. **6** (1866–1872) 82.

Chanos salmoneus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **19** (1846) 146; GÜNTHER, Cat. Fishes **7** (1868) 473; BLEEKER, Atlas Ichth. **6** (1866–1872) 81, pl. 272, fig. 4; GÜNTHER, Report Challenger Exp., Zoölogy **1** (1880) pt. 6, Shore Fishes, 61; DAY, Fishes India, (1878) 651, pl. 166, fig. 2; BOULENGER, Trans. Linn. Soc. London II **12** (1909) 291.

Lutodeira salmonea RICHARDSON, Zoölogy Erebus and Terror, Fishes (1844–1848) 58, pl. 36, figs. 1 and 2.

Butirinus argenteus and *maderaspatensis* JERDON, Madras Journ. Lit. and Sci. **15** (1849) 343, 344.

Chanos pala and *tolo* CANTOR, Cat. Malayan Fishes (1849) 278 and 282.

Chanos indicus BLEEKER, Enum. Pisc. Arch. Ind., Act. Soc. Sci. Indo-Neerl. **6** (1859) 160.

Lutodeira chanos GÜNTHER, Fishes of Zanzibar (1866) 120.

Lutodeira chloropterus PLAYFAIR, Proc. Zoöl. Soc. London (1867) 868.

Chanos chanos KLUNZINGER, Verh. Zoöl.-Bot. Gesell. Wien **21** (1871) 605; JORDAN and EVERMANN, Bull. U. S. Nat. Mus. 47 **1** (1896) 414; STEINDACHNER, Denks. Ak. Wiss. Wien **70** (1900) 514; JENKINS, Bull. U. S. Fish Comm. **22** (1902) (1903) 432; JORDAN and EVERMANN, Proc. U. S. Nat. Mus. **25** (1903) 327; JORDAN and SNYDER, Proc. U. S. Nat. Mus. **28** (1904) 123; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23**, pt. 1 (1903) (1905) 56, fig. 10; JORDAN and SEALE, Bull. Bur. Fisheries **25** (1905) (1906) 186; JORDAN and HERRE, Proc. U. S. Nat. Mus. **31** (1906) 622; JORDAN and SEALE, Bull. Bur. Fisheries **26** (1907) 4; EVERMANN and SEALE, Proc. U. S. Nat. Mus. **31** (1907) 505; JORDAN and RICHARDSON, Bull. Bur. Fisheries **27** (1908) 236; GÜNTHER, Fische der Südsee **3** (1910) 387; WEBER, Siboga Esp., Fische (1913) 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **2** (1913) 15, fig. 8; JORDAN and TANAKA, Annals Carnegie Mus. **17** (1927) 260.

Vernaular names: English, milkfish; Bicol, *bañgos;* Ilocano, *awa, banglot;* Pampango, *bañgos,* Pangasinan, *awa, betel;* Tagalog, *bañgos, bañglis, bañgris, laón, lumulokso, hatirin, garoñgin;* Samal and Tao Sug, *bangilis;* Visayan, *awa, banglus, bañgos, bañgros;* Malay, *bandang, jangas;* Javanese and Sundanese, *bandeng;* Hawaiian, *awa, awa-awa, awa-kalamoku, puawa;* Society Islands, *ava, awa;* Canarese, *hu-meen;* Tamil, *tulu caudal;* Telugu, *palah bontah;* Tulu, *pu-meen;* Arabic, *anged, anget;* Spanish, *sabalo.*

Names of bañgos fry: Ilocano, *bugi;* Pampango, *ka-kawag;* Tagalog, *kawag-kawag;* Visayan, *awa-awa.*

Dorsal II, 12 or 14; anal II, 8 or 9; pectoral I, 15 or 16; ventral 1, 10 or 11; seales in lateral line 75 to 85 + 5 to 11 on

caudal base; 12 or 13 scales above lateral line to origin of dorsal, 10 or 11 below to origin of anal; vertebræ $26 + 18 = 44$.

Body elongate, compressed, thicker with age; head and anterior part of trunk much broader proportionately and head relatively shorter in large old specimens; depth 3.5 to 3.75 in length; head 3.5 to 3.8 in length, equal to or less than depth; snout broad, usually about three-fourths in eye, 4.1 to 4.55 in head; eye large, 2.75 to 3.5 in head, usually 3.25 to 3.5; in the young the broad flat interorbital equals the eye; in mature or large specimens it becomes rounded and is a fourth or nearly half again as broad as the length of the eye; maxillary broad, slipping under the adipose preorbital, without a supplemental bone; dorsal nearer base of caudal than tip of snout (not nearer snout as stated by Jordan and Evermann; their figure is correct); dorsal with a large scaly basal sheath which is elongated posteriorly, the anterior falcate ray 1.32 to 1.42 in head, the last ray produced in a short filament; the anal resembles the dorsal but is very much smaller, its height 3.36 to 5.9 times in the head; the least depth of the powerful caudal peduncle is 2.7 to 2.85 times in the head in young, 3.3 times in adult or nearly mature specimens; the caudal is very large and deeply forked, the upper lobe slightly larger, 2.44 to 2.88 times in the length, not forked to the base as stated by many authors; the pointed pectoral is 1.85 to about 1.6 times in the head; the pointed axillary scale above 1.5 to 2 times in the pectoral, the axillary scale below much shorter; the ventral is 1.85 to 2.15 times in the head, its pointed axillary scale about 1.8 times in its own length; below each ventral is a very wide pointed scale. The caudal is not included in the length.

The color in life is brilliant silvery over all, brilliant glossy blue or bluish olive above, the top of the head yellowish olive, the sides whitish, the underside of the head white; side of the head with golden glints and opalescent luster; golden luster also along sides on some specimens; dorsal more or less yellowish, and yellowish along the mid-line of the back behind the dorsal; the fins colorless or the pectorals, ventrals, and anal more or less yellow; the caudal gray or colorless with a blackish posterior margin, or the lower lobe yellowish. Some specimens have the inside of the pectorals and ventrals dusky to black.

The color in alcohol is bluish above, the lower half merging gradually into white underneath, a brilliant silver luster over all; the fins all whitish, or the dorsal and caudal dusky, the eye

more or less deep reddish yellow; after many years specimens may turn reddish brown above, pale brownish below; large specimens have the dorsal, caudal, and tip of anal dusky, the inside of the pectorals and ventrals blackish.

Adult bañgos are from about three-fourths of a meter to a meter and a half in length, exclusive of the caudal fin. Specimens of this size differ much from the young in the shape of the top of the head and the anterior portion of the body. Specimens a meter or more in length are much bulkier in proportion, and at the shoulder girdle may be as large round as a man's thigh. The top of the head is flat in the young and becomes convex in the adult.

INDUSTRIES ALLIED TO BAÑGOS GROWING

There are three industries that are often correlated with the rearing of bañgos and which can be developed with it to a much greater extent than is done at present.

NIPA THATCH

Nipa occurs naturally along esteros in many fishpond districts, and does well planted as a screen to protect the dikes from floods and the effects of strong currents. In many localities much more could be grown than is there at present. By increasing plantings to the capacity of the ground, additional income from the sale of nipa thatch could be derived at very little more trouble and expense. Nipa thatch sells at present for 10 to 15 pesos a thousand.

FUEL FROM MANGROVE

When fishponds are located in mangrove swamps the dikes should be protected from tides, floods, and currents which threaten to undercut or erode the bank, by planting one or more rows of mangrove. A limited number of mangrove trees can also be planted along the main dikes of the pond system. Bacaoan, or mangrove, is a hard wood which is in steady demand for fuel, and from which excellent charcoal is made. At present charcoal from bacaoan sells for 2 to 2.50 pesos a sack. In a good-sized fishpond system a small but steady income could be derived from the sale of either fuel or charcoal, if the dikes were protected along the outside by a belt of properly handled mangrove trees. The Bureau of Forestry would gladly advise fishpond owners as to the best methods of handling mangrove or nipa.

SALT MAKING

The most important allied industry and one closely related to bañgos culture is making salt by solar evaporation. Many of the ponds about Bulacan, Malolos, Obando, Navotas, Malabon, and Parañaque are used to rear bañgos during the rainy season and for salt making from early in February until the middle of May.

First a part of the ground in a fishpond is divided into a series of small plots (Plate 16 and text fig. 2). The first plot is 30 meters square, followed by a narrow one of 4 by 30 meters; then comes a row of four plots, each 30 meters square, and another one 4 by 30 meters. The last plot is also 30 meters square and is divided into small blocks each 2 by 4 meters. Each block, called banig, or mat, is made as follows: The earth is first excavated to a depth of about 125 millimeters, then filled in with 100 millimeters of gravel, over which is placed a layer of clay about 25 millimeters thick. On this is placed a layer of pieces of broken tinajas, or earthenware jars, fitted together to form a smooth hard floor. Between the banig, or blocks, are the channels for conducting salt water, and along the sides of the whole compartment are drainage ditches to carry off the surplus water.

The water is let into the first compartment to a depth of about 30 centimeters. Later in the same day it is admitted to the second compartment. After remaining in these two compartments for twenty-four hours the water is let into the four succeeding compartments, remaining in each one for twenty-four hours. Compartments three and four are subdivided lengthwise into four equal parts, compartments five and six into three each. The water is then let into the narrow seventh compartment and from it runs into the last one. By that time it is only about 10 centimeters deep. Water let into the last division has evaporated to salt by late afternoon or earlier. It is scraped into piles to facilitate handling and promote drying beneath, then gathered into a large basket called tiklis. In a good season one banig, or unit, yields one tiklis of salt, worth 50 centavos. At this rate a salt pond a little more than half a hectare in area will yield from 300 to 400 pesos' worth of salt during the season.

FISH PONDS UNDER THE BUREAU OF FORESTRY

Permits to operate fishponds have been issued by the Bureau of Forestry under the provisions of Section 1838 of the Adminis-

trative Code in the following provinces: Bohol, Bulacan, Camarines Sur, Capiz, Cavite, Cebu, Davao, Ilocos Norte, Iloilo, Marinduque, Masbate, Mindoro, Misamis, Occidental Negros, Oriental Negros, Pampanga, Pangasinan, Rizal, Sorsogon, Tayabas, Zambales and Zamboanga. Most of the 390 permits granted are for small areas in mangrove swamps, and most of the permittees are still busy gathering firewood, nipa, timber, or forest products in the area covered by their permits. The only provinces in which the permits granted by the Bureau of Forestry are of any importance in the production of bañgos are Cebu, Iloilo, Mindoro, and Pangasinan. The table appended, which had been compiled by the Bureau of Forestry from reports submitted by fishpond lessees and permittees, shows that the returns per hectare of the fishponds on the Bureau of Forestry lands are very low and that the value of the fry is disproportionately high to the returns obtained. For example, compare the value of the fry released in Pangasinan with the value of the fish marketed.

The gross returns for bañgos per hectare are highest in Mindoro, over 70.84 pesos per hectare. The next highest are 40.90 pesos in Pampanga, 23.46 pesos in Pangasinan, 18.50 pesos per hectare in Iloilo, and 16.03 pesos in Cebu. The returns in other provinces are so low that it is very evident the fish were raised at a lost. If any thing is charged for interest on the cost of the dikes, for time, and for labor, the owner would have been better off without a fishpond. Money received for firewood probably enabled some of the permittees to operate with a gain.

Deducting nothing for labor, management, or the cost of dikes, and omitting returns for firewood, the table shows that the average returns for bañgos fishponds operated under Bureau of Forestry leases was 11.64 pesos per hectare for 1926. The average cost of the dikes on the same fishponds was a little over 51 pesos per hectare. At this rate, with no charges for labor, management, repairs, or improvements, it would take five years to pay for the cost of the dikes. Taking the provinces singly the table shows that the returns from bañgos will pay for the dikes, allowing nothing for any expenses or interest, in from one and a half years (Masbate), and three and a half years (Iloilo), to many years in some of the provinces, even if Tayabas is excluded. This is a very unfavorable showing as compared with privately owned fishpond lands, but it would be very unfair to compare the two as yet, since most of the

Bureau of Forestry fishpond operation, compiled from reports submitted by lessees and permittees during the year 1926.

Province.	Dike.		Fish.			Firewood invoiced.	Trees planted.	Reports submitted.	Actually granted.	
	Length.	Cost.	Fry released.	Value of— Fry.	Value of— Fish harvested.				Permits issued.	Area.
	Meters.	*Pesos.*		*Pesos.*	*Pesos.*	*cu. m.*				*Hectares.*
Bohol								1	1	3.80
Bulacan	934		1,000	14.00	80.00		10,000	1	4	34.27
Camarines Sur									1	4.00
Capiz	888	760.00	200	12.00	100.00		400	4	8	49.97
Cavite	254	1,524.00	400	12.00	60.00			1	1	.27
Cebu	25,085	25,697.46	151,850	1,068.61	5,277.65	95.00	3,630	98	144	262.46
Davao	600	2,800.00			50.00			1	4	59.61
Ilocos Norte									2	11.57
Iloilo	48,409	73,072.42	931,150	4,683.00	28,369.67	707.00	1,053	35	56	1,279.89
Marinduque									2	13.10
Masbate	177	565.00	13,000	265.00	735.00		500	5	5	53.90
Mindoro	686	2,622.00	520,800	120.00	4,100.00	358.00	20,700	2	4	56.18
Misamis									1	16.00
Occidental Negros	4,165	3,645.00	25,000	25.00	335.00	60.00	72,000	5	13	104.90
Oriental Negros	2,706	3,848.00	10,000	180.00	350.00	64.00	50	5	7	144.08
Pampanga	1,424	2,300.00	8,000	150.00	600.00		100	1	1	11.00
Pangasinan	48,083	25,221.83	385,200	1,497.30	3,364.00	5,008.04	3,426	79	111	795.60
Rizal									1	.46
Sorsogon									1	4.50
Tayabas	1,562	12,000.00	40,000	100.00	80.00	223.00		2	6	79.35
Zambales	2,504	1,818.00	11,200	37.00	78.00		650	9	16	53.78
Zamboanga									1	3.00
Total	137,477	155,873.71	2,097,800	8,163.91	43,579.32	6,515.04	112,509	249	390	3,041.69

fishponds on Bureau of Forestry lands are very new, as yet undeveloped, and have not had time to be placed on a paying basis. The life of a fishpond lease from the Bureau of Forestry is but ten years, but this may be extended to another ten years, when the property automatically reverts to the Government. During this second ten years the lessee may expect to reap a reasonable profit on his investment, and should have his lease further extended where he has complied with all the Bureau of Forestry regulations.

In the few provinces where constructed fishponds were already inspected by the Bureau of Forestry, it was found that all the mangrove trees, except narrow strips reserved for protection purposes along seashores or river banks, had been cleared as it is considered by many fishpond operators that the existence of mangrove trees within the pond is not conducive to the growth and development of milkfish. The cutting and utilization of mangrove trees within the area under permits before converting the same into fishponds are permitted under certain conditions.

It is therefore clear that from the first to the third years' operation of the permittees, they spend most of their time in removing and utilizing the forest growths from the areas to be constructed into fishponds, and the income derived therefrom is invested in the construction of fishpond dikes.

It is apparent that the mere possession of a piece of mangrove or other swamp, and the establishment of some sort of a fishpond on it, is not necessarily a sure way to wealth; it may be merely the forerunner to bankruptcy.

However, the bañgos-fishpond business is a certain and lucrative one if the owner has sufficient capital for the proper construction of his ponds and will put into it the same energy, prudence, and thought that he would put into the successful management of any other business.

ILLUSTRATIONS

PLATE 8

FIG. 1. A fishpond with a perfect growth of lumut; a watchman's hut on the dike and nipa palms in the middle distance, on the Carlos Palanca estate, Hagonoy. April 22, 1927.

2. A fishpond showing dikes planted with mangrove, at Batang Barrio, Sexmoan, Pampanga Province, Luzon.

3. Fishponds with coco palms growing on a dike, at Paombong, Bulacan Province, Luzon.

PLATE 9

FIG. 1. Men counting bañgos fry (kawag-kawag), on the Carlos Palanca estate, Hagonoy, Bulacan Province, Luzon. April 27, 1927.

2. A nursery pond for bañgos, near Abucay, Bataan Province, Luzon. The fry are placed in the small inclosure shown in the foreground. May 3, 1927.

3. Men catching young bañgos (hatirin), near Bancal Barrio, Guagua, Pampanga Province, Luzon. The pond has been drained, and only a ditch has been left with water in it where the bañgos are crowded together and can be easily dipped up.

PLATE 10

FIG. 1. Fishponds and watchman's hut, at Samal, Bataan Province, Luzon.

2. A part of Doctor Valencia's fishponds, on Mactan Island, Cebu.

3. A part of Doctor Valencia's fishponds, on Mactan Island.

PLATE 11

FIG. 1. A poorly kept fishpond near Barotac Nuevo, the average type of pond seen in Iloilo Province, Panay.

2. A poor fishpond near Barotac Nuevo, Iloilo Province. A poorly kept nursery pond within a low dike and mangrove forest in the background.

3. Part of a good fishpond system near Dumangas, Iloilo Province, Panay. August 5, 1927.

PLATE 12

FIG. 1. A fishpond on the Polo plantation, Tanjay, Oriental Negros Province, Negros, with large dikes, and mangrove trees growing in the pond.

2. A fishpond of low salinity, less than 1 per cent, at Santo Rosario Barrio, Malolos, Pampanga Province, Luzon. Mudfish (dalag) can be found in this pond throughout the year. In the division on the right the water is almost entirely hidden by a dense growth of *Lemna*. The men are pulling up digman, aquatics of the genera *Ruppia* and *Najas*.

3. A fishpond of low salinity, never higher than 0.4 per cent, near Tinejero Barrio, Bacolor, Pampanga Province, Luzon. There is a patch of grass near the center of the pond and plenty of lumut, but this is not a first-class pond. The low salinity permits mudfish (dalag) to live in the pond throughout the year.

PLATE 13

FIG. 1. An abandoned fishpond near Hermosa Barrio, Orani, Bataan Province, Luzon.

FIG. 2. A small inclosure for catching bañgos that are ready for market. This pond has three sluice gates. Nipa palms show in the background. Malocan Barrio, Hagonoy, Bulacan Province, Luzon.

3. A small inclosure for catching bañgos that are ready for market. There are three sluice gates; the bamboo screen of the nearest gate is lifted. Carlos Palanca estate, near Hagonoy, Bulacan Province, Luzon.

PLATE 14

FIG. 1. A catching pond (koloñgan) at Duniangas, Iloilo Province, Panay, having seven gates, five of which show in the picture.

2. A corral (baklad) for catching bañgos in Doctor Valencia's fishpond on Mactan Island. A barrier of boards ordinarily prevents fish from entering the corral.

3. The corral shown in fig. 2 with a part of the board barrier removed. The two men are catching bañgos with a net.

PLATE 15

FIG. 1. A bañgos pond at Batavia, Java.

2. Dike construction and main sluice gate, Batavia, Java.

3. Caretaker's house and bañgos ponds, Batavia, Java.

PLATE 16

FIG. 1. A fishpond being used for salt making. The pond is divided into small beds. A man is scraping up the salt. Dampalit Barrio, Malabon, Rizal Province, Luzon. May 12, 1927.

2. Salt-crystallizing pond and warehouse for salt at Malabon.

3. A man gathering salt into baskets. May 12, 1927.

TEXT FIGURES

FIG. 1. Plan and elevation of a fishpond sluice gate.

2. Plan of a bañgos nursery pond, at Dampalit Barrio, Malabon, Rizal Province, Luzon. This pond is used for salt making during the dry season. Below, a fish trap (galao).

3. Plan of a part of a 20-hectare fishpond system with six 3-hectare catching ponds (kaloañgan). Paombong, Bulacan Province, Luzon.

4. Plan of a part of a 600-hectare fishpond system. The nursery will cost 4,000 pesos and will hold 1,500,000 bañgos fry (kawag-kawag). Ayala and Company, Macabebe, Pampanga Province, Luzon.

5. Plan of an 8-hectare fishpond system, showing the various parts.

6. Plan of a fishpond and small catching ponds used at Barotac Nuevo, Iloilo Province, Panay.

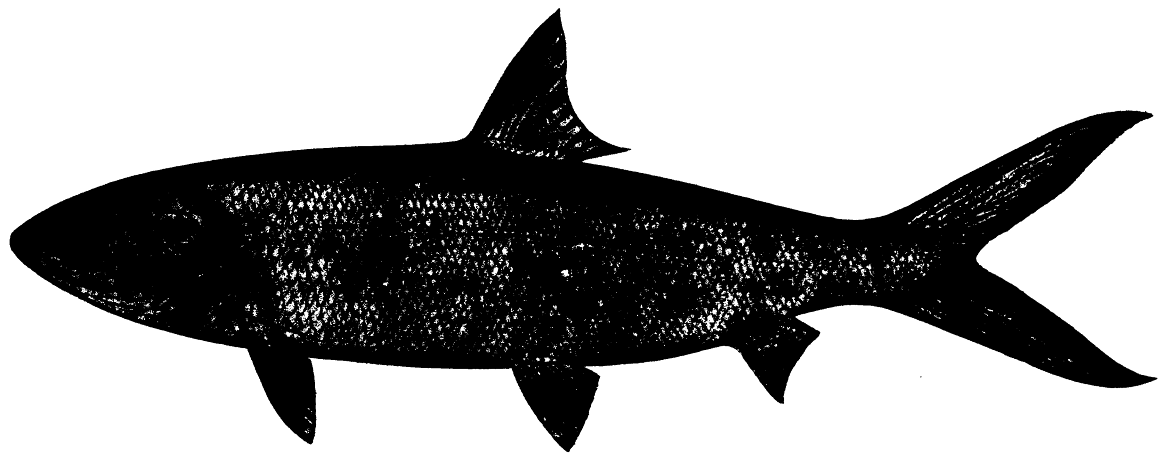

PLATE 1. BAÑGOS, OR MILKFISH, CHANOS CHANOS FORSKÅL.

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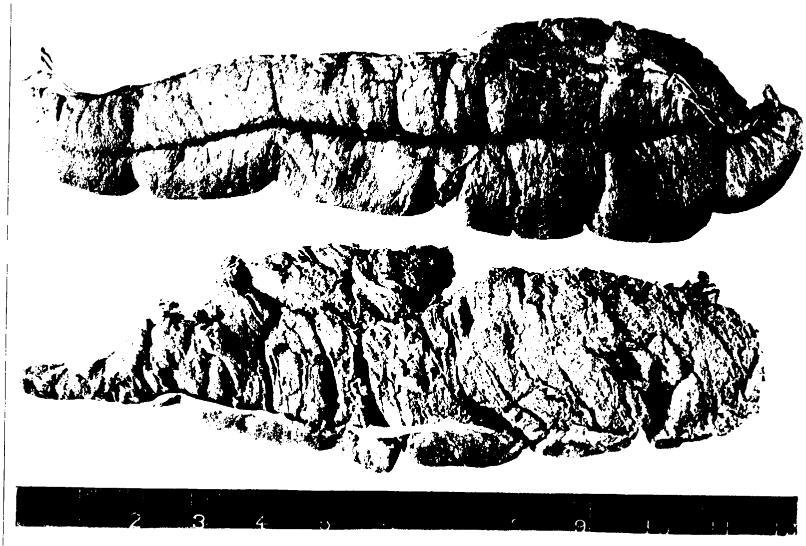

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PLATE 2.

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PLATE 3.

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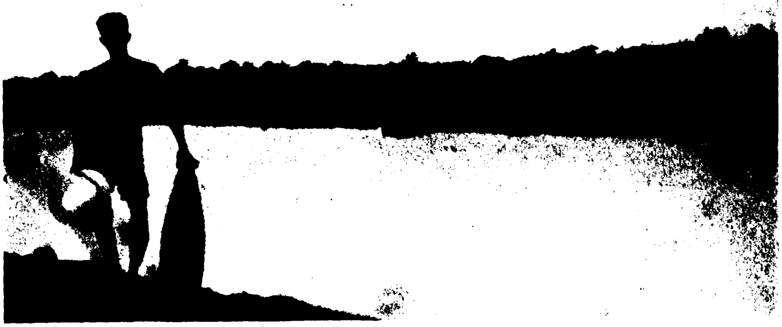
PLATE 4.



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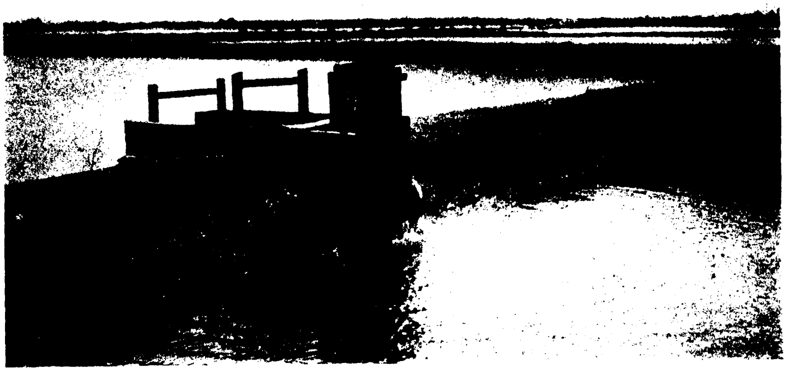

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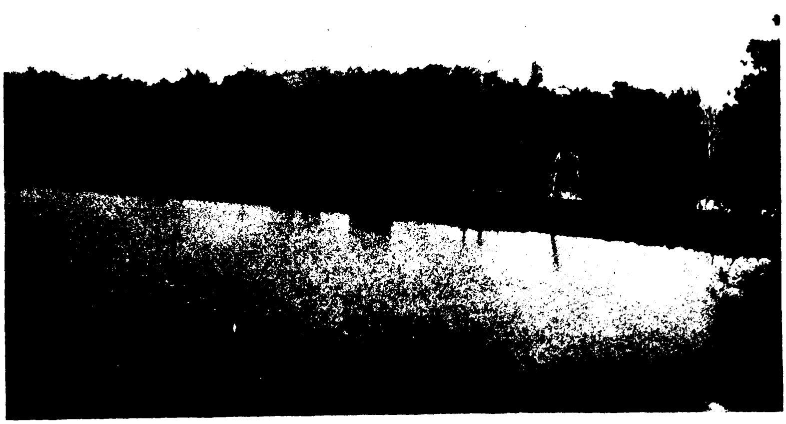

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PLATE 5.

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PLATE 6.

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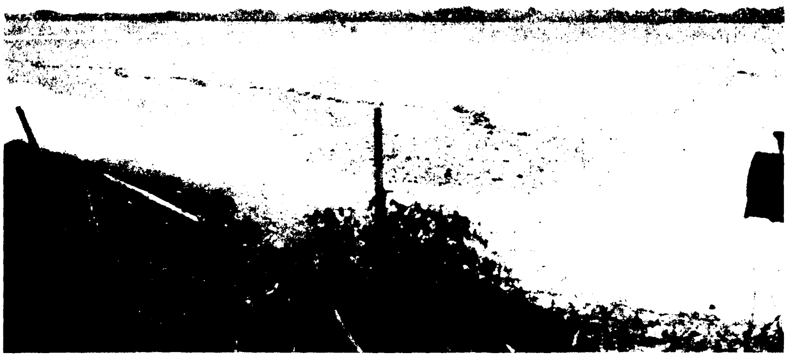

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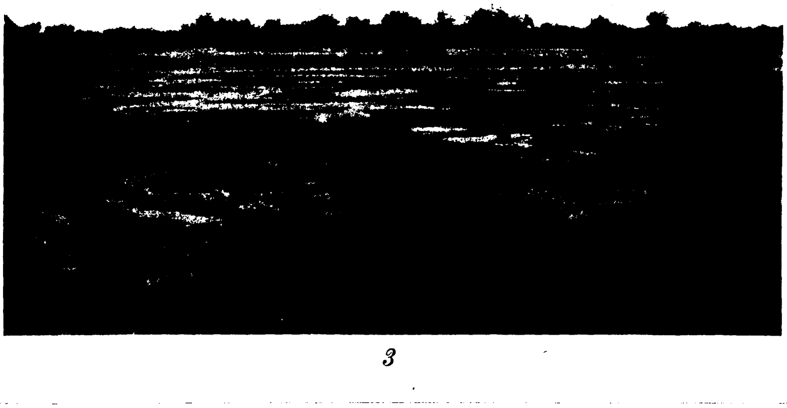

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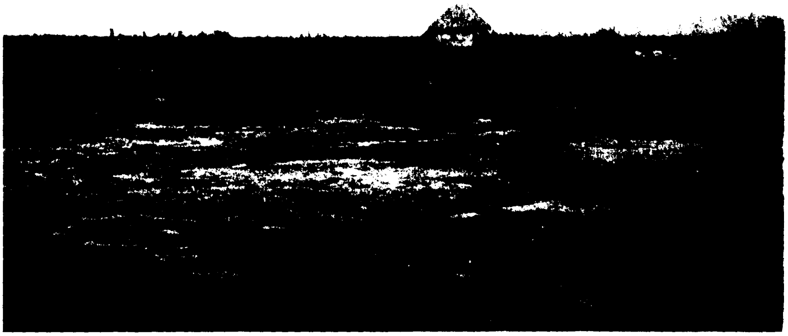
PLATE 7.



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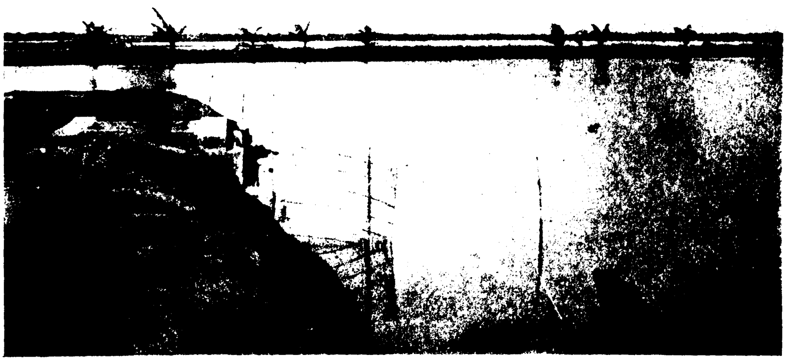

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PLATE 8.

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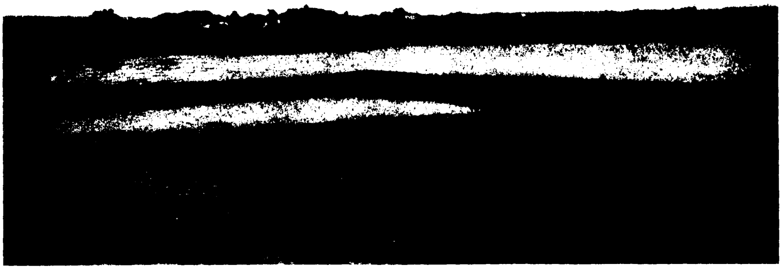

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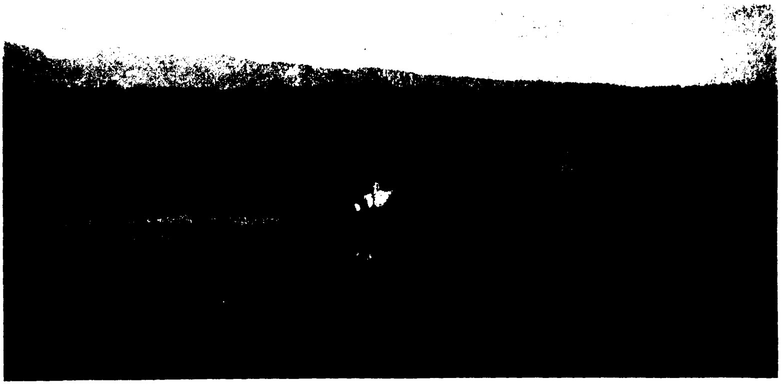

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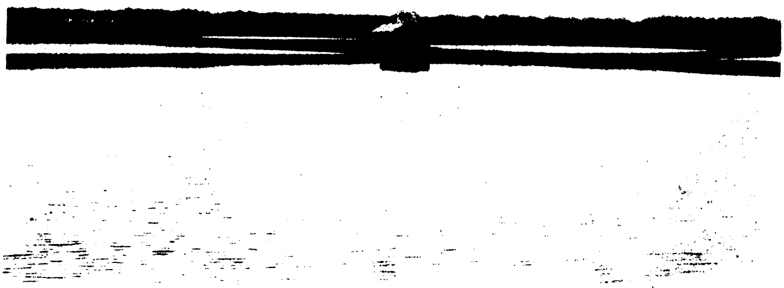

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PLATE 10.

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PLATE 11.

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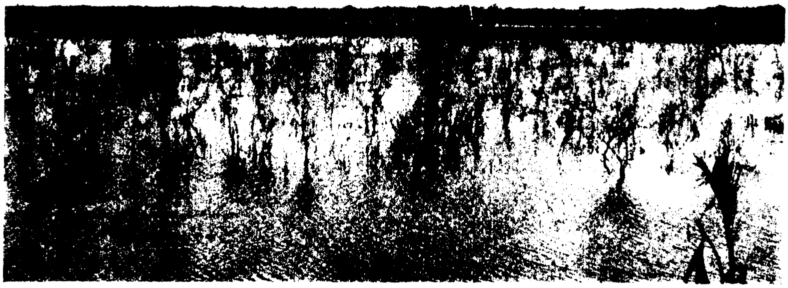
PLATE 12.



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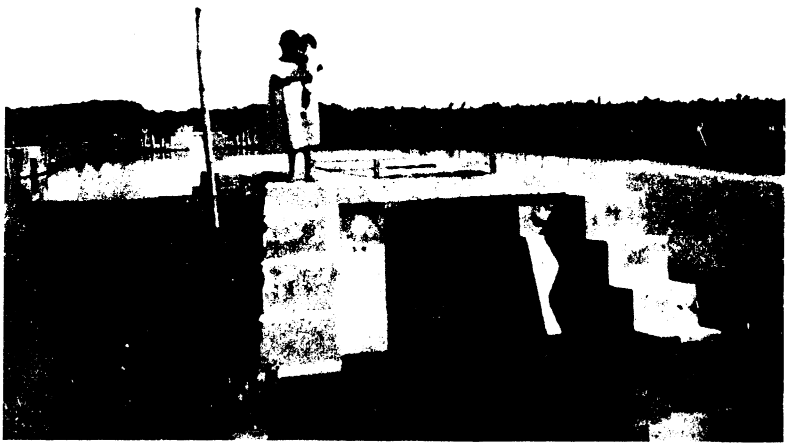

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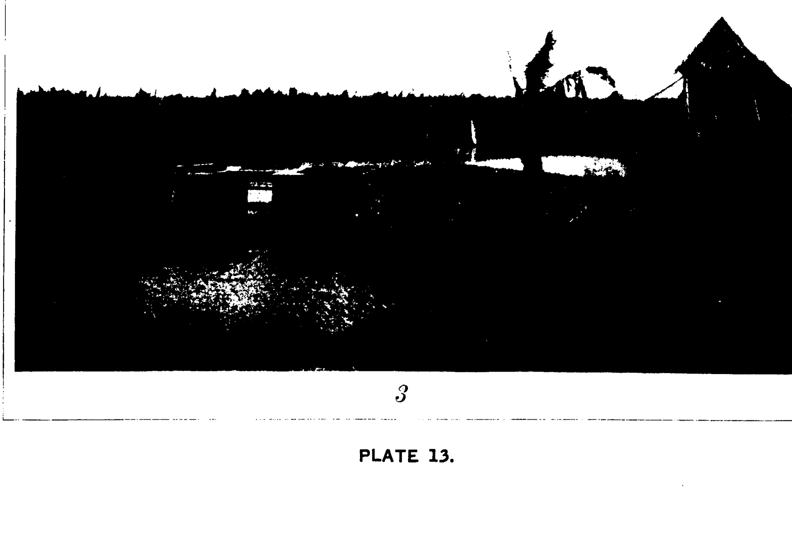

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PLATE 13.

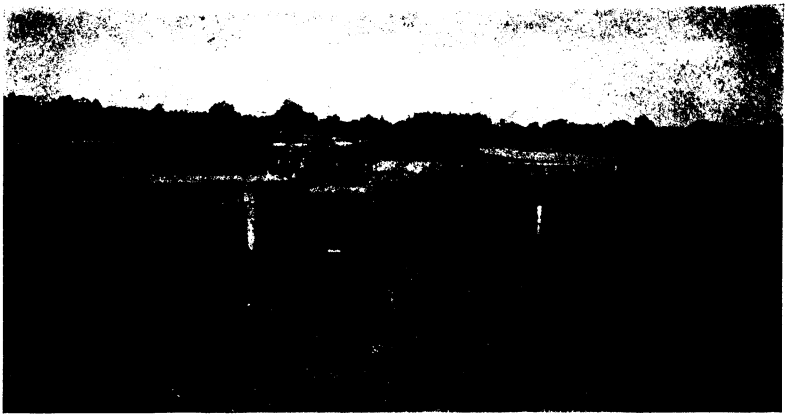

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PLATE 14.

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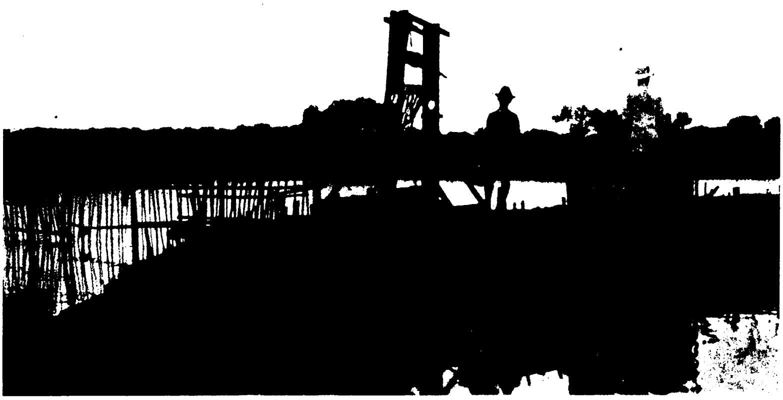

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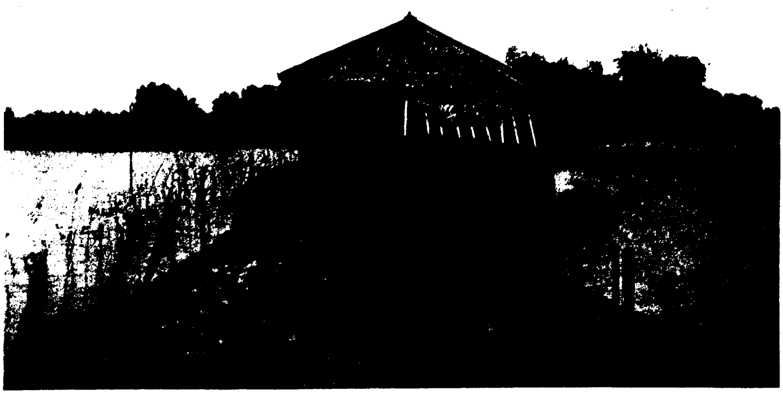

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PLATE 15.

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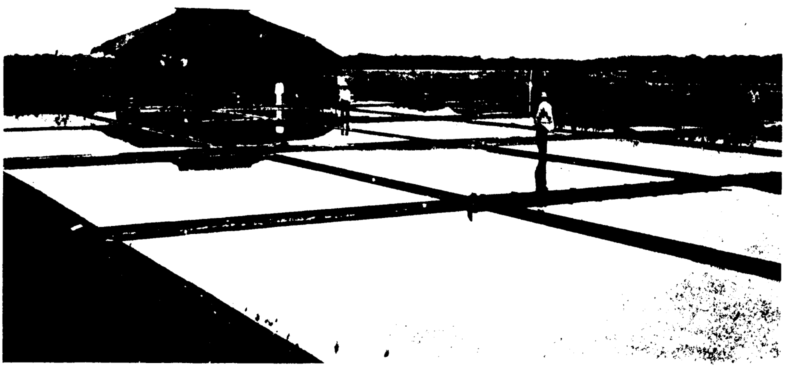

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PLATE 16.

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[New names and new combinations are printed in **boldface**.]

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